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SYMBOLS, UNITS, AND EQUIVALENTS

Symbol	Unit	Equivalent
BeV	billion electron volts	GeV
Ci	curie	3.7×10^{10} dps
cm	centimeter(s)	0.394 inch
cpm	counts per minute	
dpm	disintegrations per minute	
dps	disintegrations per second	
eV	electron volt	1.6×10^{-12} ergs
g	gram(s)	
GeV	giga electron volts	1.6×10^{-3} ergs
kg	kilogram(s)	1,000 g = 2.205 lb
km^2	square kilometer(s)	
kVp	kilovolt peak	
m^3	cubic meter(s)	
mA	milliampere(s)	
mCi/mi^2	millicuries per square mile	0.386 nCi/mi^2 (mCi/km^2)
MeV	million (mega) electron volts	1.6×10^{-6} ergs
mg	milligram(s)	
mi^2	square mile(s)	
ml	milliliter(s)	
mm	millimeter(s)	
nCi/m^3	nanocuries per square meter	2.59 mCi/mi^2
pCi	picocurie(s)	10^{-12} curie = 2.22 dpm
R	roentgen	
rad	unit of absorbed radiation dose	100 ergs/g

INTERNATIONAL NUMERICAL MULTIPLE AND SUBMULTIPLE PREFIXES

Multiples and submultiples	Prefixes	Symbols	Pronunciations
10^{12}	tera	T	tĕr' a
10^{9}	giga	G	jĭ' ga
10^{6}	mega	M	mĕg' a
10^{3}	kilo	k	kĭl' o
10^{2}	hecto	h	hĕk' to
10	deka	da	dĕk' a
10^{-1}	deci	d	dĕs' i
10^{-2}	centi	c	sĕn' ti
10^{-3}	milli	m	mĭl' i
10^{-6}	micro	μ	mi' kro
10^{-9}	nano	n	năn' o
10^{-12}	pico	p	pē' co
10^{-15}	femto	f	fĕm' to

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 8, Number 10, October 1967

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the National Center for Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the National Center for Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Reports

Diet Model For Measuring Radioactivity Exposure Through Food—Pilot Study

R. C. Steinkamp,[1] *N. L. Cohen,*[2] *E. Hutson,*[3] and *H. Kunkel*[3]

This paper reports a pilot study designed to test the hypothesis that the house diet of a hospital may serve as a model for the diet of an adult population regionally served by the hospital in order to measure radioactivity exposure through food intake. Yearly and seasonal quantities of 37 subcategories of nine major food groups were compared for a Berkeley hospital house diet and diets of Berkeley and other San Francisco Bay Area residents. Results indicate that the hospital house diets while differing in certain respects from food intake of the population, may provide an estimate of near-maximum intake of foods significant for radioactive content.

Prior to 1964, individual foods, including milk and water, produced or consumed within the State of California were monitored by the Bureau of Radiologial Health and the Sanitation and Radiation Laboratory. This system provided no knowledge of food intake and therefore the determination of radioactivity consumed through the total diet was limited. Consequently, a different approach is necessary in order to provide adequate information upon which to formulate policies protective to the general health of the population.

Readily available and accurately collected total diets representative of the population living in several areas of the State are needed for study.

Other agencies are monitoring total diets by analyzing: (1) seasonal market-basket samples (*1*) for which types and amounts of food are based on U.S. Household Consumption Records; (2) a "standard" diet in Connecticut (*2*); and (3) diets sampled from school institutions (*3*). These three approaches have merit, but not one of them satisfies the peculiar needs for continuing diet sampling programs within California.

No single "master" diet can be representative for the whole State. Diet practices differ. Areas with greater rainfall have a higher radioactive fallout resulting in higher radioactivity in foods grown within the areas. For monitoring purposes, representative diets should reflect the maximum or near maximum potential for radioactivity obtained through food. Since radioactivity varies from time to time, it is imperative that diets be available for sampling throughout the year.

In order to meet these prerequisites, house diets of 20 regional hospitals in different geographic areas of California were selected for

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Figure 1. Location of the 20 participating hospitals for radioactivity monitoring of diet in California

total-diet sampling. Figure 1 shows these locations. House diets of regional hospitals may reflect the diets of the population served by the hospital (exclusive of infants and young children). Hospitals operate and serve food each day of the year. Hospital personnel trained in dietetics are available to collect the diets. Furthermore, they are motivated toward health needs and protection of health and are willing to cooperate in sampling studies.

This study has attempted to explore the hypothesis that house diets of a given hospital may serve as a model of food consumption by an adult population regionally served by the hospital and that such diets may represent the maximum or near maximum exposure to radioactivity through food. Inherent to this hypothesis is the assumption that food sources available to the hospital and to the regional population are similar. This has also been explored. House diets of the 19 hospitals for which regional population diet records were unavailable have also been compared with the house diet of the hospital used as the basis of this study.

Materials and methods

All food constituting a single house diet (all meals and nourishments) for a 7-day period was collected every 2 months for a period of 1 year by trained personnel. Records of type, amount and preparation for each food served in a single house diet for each collection period were kept by the dietitian or another individual responsible for the collection procedure. The records for the Berkeley Hospital were the basis for this study. Food was weighed in ounces or measured in cups, tablespoons, or other household units. Recipes of composite foods were noted to obtain approximate amounts of individual foods.

Individual diet recall records for adults living in the San Francisco Bay Area obtained in a previous study (*4,5*) were used to represent diets of people regionally served by the Berkeley Hospital. The recall records denoted quantity as well as food preparation methods and composition of mixed dishes. One-day records for 483 men and women, aged 25 to 44 years, were divided according to three areas of residence: Berkeley, other Alameda County, and other Bay Area.

Table 1 presents the number of menus for all hospitals and the number of individual consumption records based on 1-day food recalls for the various population groups on a bimonthly interval. The Berkeley Hospital records were complete for all time intervals. Occasionally, throughout the year, records were not complete for several of the other hospitals. Appropriate corrections were made to account for only complete records.

The amounts of food recorded for the Berkeley Hospital menus and for individual subject records were compared for 100-gram portions

Table 1. Number of weekly menus and individual food-recall records by month of year

	Jan–Feb	Mar–Apr	May–June	July–Aug	Sept–Oct	Nov–Dec	Total days
Hospital weekly menus	19	17	20	19	20	18	791
Individual 1-day recall records:							
Berkeley	9	3	13	25	82	10	142
Other Alameda County	6	23	50	44	16	11	150
Other Bay Area Counties	12	57	52	36	27	7	191

Table 2. Food categories by radioactive fallout potential

Milk and milk products
- Fresh whole milk
- Fresh skim milk
- Canned milk
- Dry skim milk
- Cottage cheese
- All other cheese
- All other dairy products, including ice cream and sherbet
- Creamed dishes and creamed soups

Animal protein foods
- Beef, pork, lamb, veal, organ meats, poultry
- Fish
- Shellfish
- Bacon and sausage
- Eggs

Legumes
- Dried peas, beans and nuts

Vegetables
- Leafy green
- Underground vegetables, including mixed vegetables
- Above ground vegetables
- Kernel corn

Fruit
- Not peeled, including jams and jellies
- Peeled

Grain products
- Whole grain products, and those with any proportion of whole grain, including corn meal
- Refined cereal products

Combination foods
- Fruit pie
- Cream pie
- Other pie
- Meat and grain products
- Meat and vegetables
- Meat, vegetables and grain products

Fats and oils
- Vegetable oils and salad dressings
- Margarine
- Butter
- Animal fat

Miscellaneous
- Honey
- Gelatin and plain gelatin products
- Gelatin with fruits or vegetables
- Soups other than creamed
- All other foods and beverages

and were coded within nine major food groups with a total of 37 subcategories (table 2) arbitrarily grouped according to similarity of potential for radioactive fallout or pesticide residue.[4] Similar comparison was made for the Berkeley Hospital menus and the averages for menus of the 19 other hospitals by time interval.

A questionnaire was administered to the hospital food buyer to determine sources, brands and purchasing practices of food. A similar questionnaire was administered to the managers and buyers of three large food chain stores and two neighborhood food stores[5] in Berkeley in order to determine food sources

[4] Performed by Food and Drug Laboratory on selected samples of diets.

[5] The Berkeley Market, Consumers Cooperative of Berkeley, Lee Brothers Market, Safeway Stores and Varsity Food Market.

available to the reference population group. These markets represent the major retail food stores in the Berkeley area. Additional information was obtained from wholesale food companies.

Analysis of purchasing practices provided for comparison of the sources of foods available to the Berkeley Hospital with those available to the reference population through the local markets.

Results

Table 3 presents the yearly means and ranges in 100-gram portions per day for nine major food groups for the Berkeley Hospital and the Berkeley residents. Results of the other two population groups were similar to those for the Berkeley residents. The Berkeley Hospital menus had a smaller range for all food groups except milk and milk products than any one of the three population groups. The exception for milk is explained by the fact that during the first months of collection, fluid milk was not included in the collection sample each time it was available on the house diet menu. For only three food groups (animal protein foods, legumes, and combination foods) was the mean daily serving per year lower for the hospital house diet than for the Berkeley residents. The Berkeley Hospital menus provided a daily average of 206 grams of animal protein foods, 4 grams of legumes and 42 grams of combination foods. Comparable figures for the Berkeley residents were 213, 11, and 81 grams, respectively. Miscellaneous foods comprised for the most part, coffee, tea, and soups other than creamed soups. No gelatin was used by the Berkeley Hospital or the general population.

Table 3. Means and ranges for major food groups in 100 g portions/day for the Berkeley Hospital and the Berkeley residents

Food groups	Berkeley Hospital		Berkeley residents	
	Mean	Range	Mean	Range
Milk and milk products	6.34	4.18– 8.29	3.59	2.00– 5.48
Animal protein foods	2.06	1.85– 2.21	2.13	1.39– 2.90
Legumes	.04	.01– .09	.11	0– .32
Vegetables	3.76	3.22– 4.39	1.97	1.22– 2.76
Fruits	2.88	2.14– 3.44	2.17	1.25– 3.43
Grain products	3.48	3.21– 3.93	2.21	1.10– 3.48
Combination foods	.42	0– .90	.81	0– 3.00
Fats and oils	.54	.50– .61	.27	0– .50
Miscellaneous	12.44	8.09–24.80	11.80	1.20–24.40

Alcoholic beverages were included in miscellaneous foods for the general population but did not appear on hospital menus.

While the average daily amount of all milk and milk products used by the Hospital was almost twice that of the Berkeley subjects, 634 grams as compared to 359 grams, the average amounts of fluid whole milk were quite similar, 236 and 222 grams, respectively. Means and ranges were also comparable for cottage cheese and all other cheese. The Berkeley Hospital used more canned milk, creamed dishes (including soups) and other dairy products (excluding butter) than did any of the three population groups. On the other hand, skim milk was not used by the hospital. The Berkeley and other Alameda County residents used about 40 grams of skim milk a day and all other Bay residents almost 100 grams.

The average daily animal protein food intake was remarkably similar for the hospital and the general population. There were slight variations among the sub-categories for this food group. The general population used more lean meats and fewer eggs than did the hospital, 145 and 33 g/day as compared to 123 and 53 g/day, respectively. The hospital used no shellfish; the general population's diets averaged 3 g/day.

Considerably less use was made of legumes in the hospital diet than in the population diets. The hospital menus had greater quantities of all other vegetables than did those of the resident groups. For leafy green vegetables, vegetables grown underground and those grown above ground, the hospital average was almost twice that of the population. Hospital use of kernel corn was only slightly higher than that used by the population.

Seasonal variation for 15 of the 37 food groups is presented in figure 2 for Berkeley Hospital menus, for averages of menus of 19 other hospitals, for the Berkeley residents, and for all Bay Area residents. Food groups not shown in figure 2 were used in average amounts of less than 25 grams a day (fruit pie, cream pie, other pie, honey, fish, shellfish, animal fats, cottage cheese, and all other cheese), or were completely absent from the diets of either the hospital or the general population (combination dishes of meat and grain, plain gelatin, gelatin

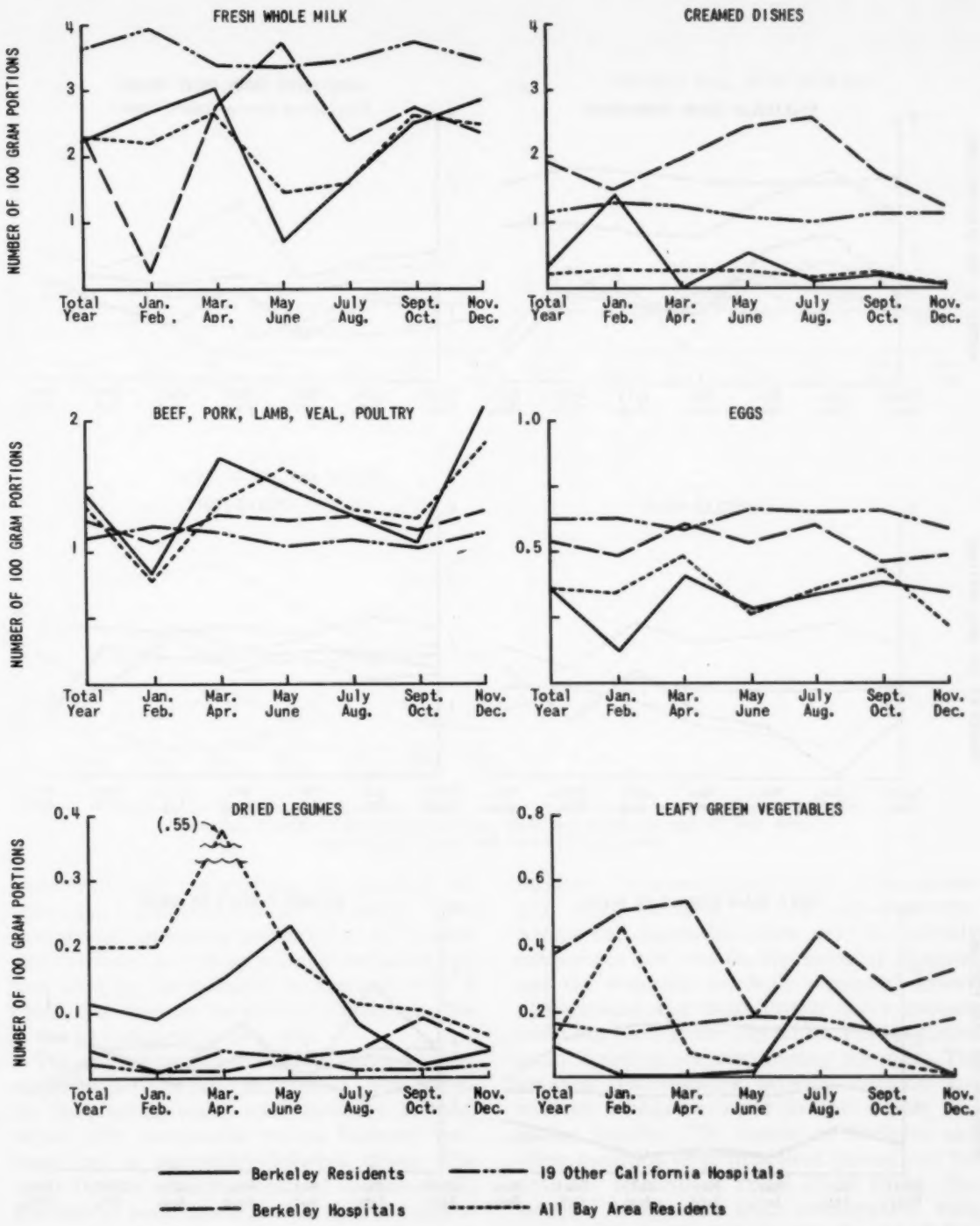

Figure 2. Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

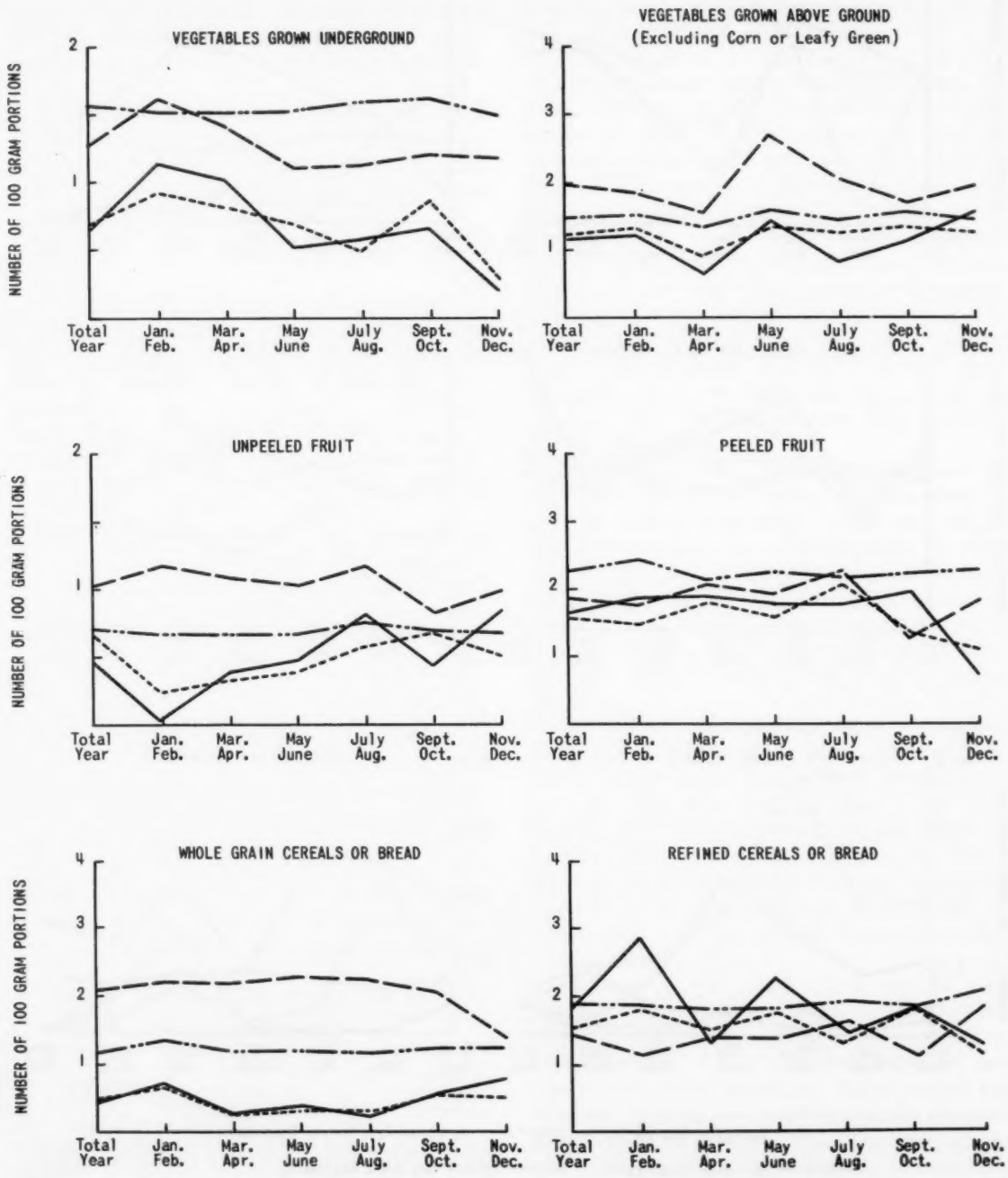

Figure 2. Continued—Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

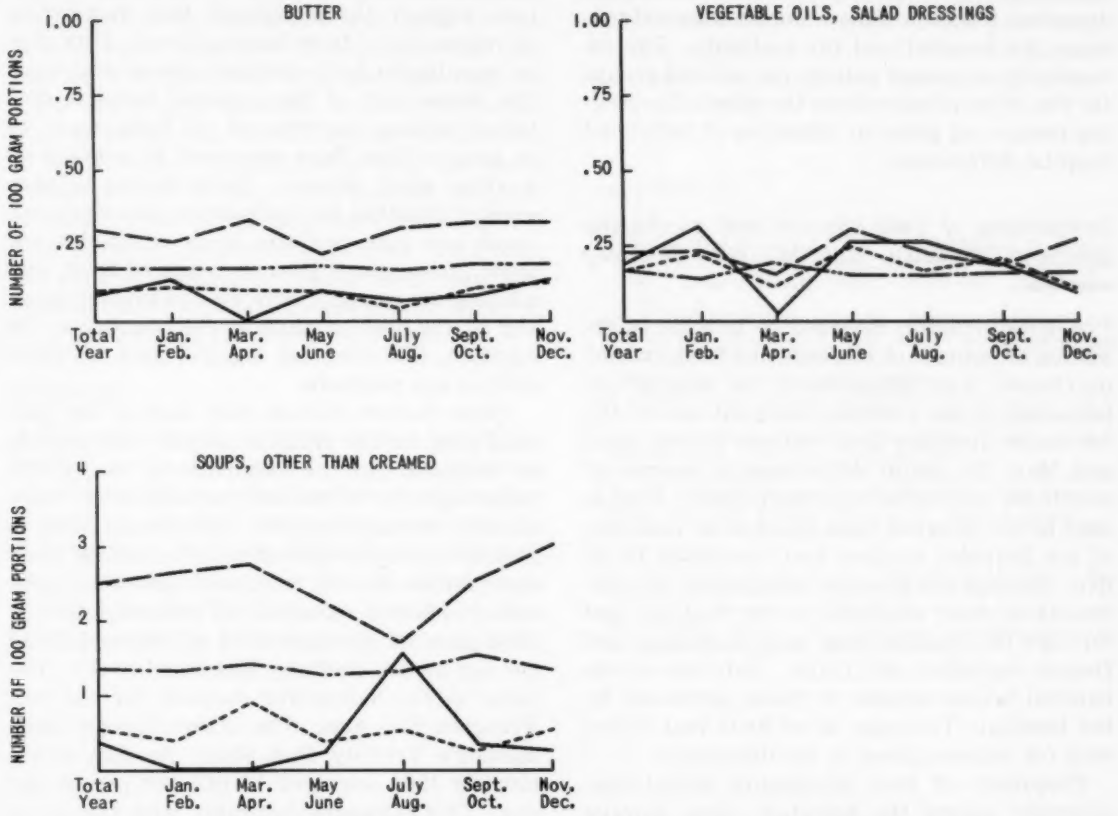

Figure 2. Continued—Daily food group means in 100-gram portions for a Berkeley Hospital, 19 other California hospitals, Berkeley residents and all Bay Area residents by year and bimonthly intervals

with fruit, and margarine). In addition, all other dairy products are not presented. This food group, consisting primarily of ice creams and sherbets, showed no seasonal variation and was used by the hospital in amounts over 5 times that used by the general population, 164 g/day as compared to 30 g/day.

The 15 food groups in figure 2 comprised the major part of the total daily menu. The Berkeley Hospital showed a wide variation in fresh whole milk, comparable to the Berkeley residents but at seasonally different times. The nadir for the residents occurred in May–June; the time of peak appearance of milk in hospital menus. Lean meats and eggs were at steady levels throughout the year for the Berkeley Hospital as well as all other hospitals. For the residents, the lowest consumption of lean meats and eggs occurred in January–February. Among the vegetables there were remarkably comparable patterns for the Berkeley Hospital and the residents for both vegetables grown underground and those grown above ground, excluding leafy green vegetables. For the latter, great variation occurred during the year. The greatest discrepancies between hospital and resident menus occurred in the winter and spring months. The menus of Berkeley and other hospitals were consistent throughout the year for amounts of fruits of all kinds. The seasonal trends for fruit consumption were comparable for Berkeley residents and all Bay Area residents; for peeled fruits all menus were similar to the Hospital menus. Little variation

was found for whole grain cereals or breads for any groups of menus. Butter, oils, and salad dressings tended to follow similar seasonal patterns for hospital and for residents. The remarkably consistent pattern for all food groups for the 19 hospitals reflects the effect of averaging menus and gives no indication of individual hospital differences.

Comparison of food sources and purchasing practices—Berkeley Hospital and Berkeley markets

A questionnaire, designed to provide information on sources of all foods and frequency of purchases, was administered to appropriate personnel of the Berkeley Hospital and of the five major Berkeley food markets during April and May. No major differences in sources of supply for individual foods were found. Brands used by the hospital were found in at least one of the Berkeley markets and frequently in all five. Perhaps the greatest discrepancy between brands of food available to the hospital and through the markets was seen in canned and frozen vegetables and fruits. Only two stores handled brands similar to those purchased by the hospital. This may be of little real difference for reasons given in the discussion.

Frequency of food purchasing varied considerably among the hospitals, since storage facilities determine to a large extent their buying practices. In general, the Berkeley Hospital bought perishable foods 3 to 4 times a week, while frozen meat, poultry, and fish were bought once a month. Bread was purchased 5 to 6 times a week. Staples such as sugar, all canned foods, dehydrated foods, cereals, and oils were bought 4 to 6 times a year and flour once a month. Fresh, as well as frozen fruits and vegetables, were purchased 2 to 3 times a week.

The major difference between purchasing by food markets and by the Berkeley Hospital was that, in general, the food markets bought all foods more frequently than did the hospital.

Discussion

Estimates of diets representative for a population group are possible provided consideration is given to details of population sampling, to accuracy of diet intake studies, and to careful statistical procedures. The results presented here support the hypothesis that monitoring of radioactivity from hospital house diets may be meaningful for population intake estimates. The house diet of the regional hospital contained average servings of all foods equal to or greater than those consumed by a group of working adult persons. Foods known to have greater potential for radioactive contamination (milk and milk products, leafy vegetables and those grown above ground, unpeeled fruit, and whole grain cereals) were used in greater quantity by the hospital than by the population. In addition, the reference hospital used no dried milk or egg products.

These factors indicate that diets of the hospital used in this study as a reference provide an indication of the maximum or near-maximum exposure of the adult population to radioactivity through the diet. Additional study is needed to extend this estimate to include other age groups; that is, teenagers, school and preschool children. Analysis of radionuclides for 1964 gave an average of 19 pCi strontium–90 per day for the Berkeley Hospital diet (*6*). The latter is the monitoring location for the San Francisco Bay Area. The Atomic Energy Commission's Tri-City Diet Study for San Francisco in 1964 averaged 14 pCi per person per day. This compares favorably with the above results.

Additional support for the use of hospital house diets for radioactivity monitoring of population exposure through diet is provided by the data on sources of food available to the hospital and to the general population. For the majority of foods, the places of origin available to hospitals appear to be similar to those in the local markets. Several factors were identified which may indicate that the sources of supply were even more similar than is evident. Chain food markets often use their own label for the same products sold in the area by others under a different label. Vegetables and fruits, picked from the same crop, may be packaged under several different labels. Labels for foods packed in large quantity as used by hospitals may differ from labels used for smaller-sized containers as sold in retail stores, although the foods may originate from the same crop.

One factor needing further investigation is the storage life of foods as used in hospital house diets with relation to that used by the general population. It is conceivable that certain of the short-lived radionuclides may be lower in hospital diets as a result of longer storage before use. This, however, would seem to be of minor importance as long as above ground nuclear testing is not resumed. Another possible factor is the likelihood that hospitals may use dried milk and eggs more often than the general population. These foods may contain radioactive contaminantes from a different time period than fresh milk and eggs.

Conclusion

This pilot study suggests that a model for measuring the near-maximum intake of foods significant for the determination of radioactive content of an adult population group may be derived from the house diet of a hospital serving the region from which the population group is selected. Additional study needs to be done using a randomly selected population group including children as well as adults. Other geographic regions should be investigated in order to substantiate the findings of this pilot study. Sources and storage life of foods must be more completely evaluated than was possible here.

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Technical Notes

Plutonium and Strontium-90 in Precipitation, August 1966 through March 1967

H. Levine, W. P. Kirk, and *H. J. L. Rechen* [1]

The Radiation Surveillance Network (RSN) of the National Center for Radiological Health, U.S. Public Health Service, Rockville, Md., initiated in August 1966, routine measurements of the amounts of total plutonium and strontium–90 in precipitation samples as part of its mission to establish, maintain, and operate a national surveillance network to report radioactivity in surface air and precipitation (*1*). These measurements are concurrent with the measurements of plutonium in airborne particulates initiated in 1965 and reported previously (*2*). Plutonium and strontium–90 are long-lived nuclides injected into the atmosphere, principally by the detonation of nuclear devices (*3*). Plutonium analyses of precipitation samples are done partly for comparison with data from corresponding air samples and because together with the analyses for strontium–90, they provide an indication of the deposition of long-lived radionuclide fallout by precipitation in the United States.

Eight RSN stations submit complete collections of precipitation for analysis. Funnels of 0.4 m^2 area are used to collect 24-hour precipitation samples. The daily collection, if any, is measured, placed in one or more plastic containers and mailed to the NCRH Special Studies Laboratory at Rockville, Md. Upon receipt at the laboratory, 500 ml or 50 percent of the mixed sample (whichever is less) is evaporated to dryness on a 10-cm diameter planchet and the gross beta radioactivity is counted in a thin-window, low-background, gas-flow proportional counter. The remainder of the sample is set aside until all samples for that month have been received. After the total monthly volume of precipitation for the station is known, a monthly composite sample is prepared for each station by combining calculated quantities of each of the daily samples in an 18-liter carboy.

A 100- to 1,000-ml aliquot is taken from each monthly composite and sent to the Southeastern Radiological Health Laboratory to be analyzed for tritium. The remainder of each composite is analyzed for total plutonium using the procedures of Levine and Lamanna (*4*) as modified below and for strontium–90 with standard procedures (*5*).

The samples are evaporated to dryness, and the residues are brought completely into solution with nitric acid—hydrofluoric acid treatment, converted to the chloride ion and brought to volume in a volumetric flask. The solution is then divided into two aliquots, 70 percent and 30 percent, and each aliquot undergoes analysis separately for total plutonium. The

[1] Mr. Levine is chief radiochemist, Electronic Products Radiation Laboratory, Technical Services Branch, NCRH; Mr. Kirk, chief, Radiation Surveillance Network, Environmental Surveillance and Control Program, NCRH; and Mr. Rechen, deputy chief, Electronic Products Radiation Laboratory, TSB, NCRH.

Table 1. Plutonium and strontium-90 in precipitation, August 1966–March 1967

	Station location							
	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Honolulu	Seattle
Precipitation depth (mm)								
1966								
August	45	41	55	259	101	28	16	3
September	101	46	34	203	102	42	0	33
October	96	46	16	80	25	3	18	40
November	22	46	7	12	2	7	55	94
December	50	71	0	138	20	4	70	148
1967								
January	69	32	0	89	6	12	33	150
February	81	40	0	35	30	3	102	31
March	61	97	0	31	22	17	168	70
Total plutonium concentration (pCi/liter)								
1966								
August	0.012	0.031	ND	0.016	0.015	0.020	0.022	(a)
September	.018	.036	ND	.014	.012	.011	NS	ND
October	.012	.020	(a)	.012	ND	(a)	.009	.007
November	.020	.012	(a)	.017	(a)	(a)	.008	ND
December	.023	.008	NS	.007	.008	(a)	.004	.004
1967								
January	.015	.014	NS	.016	(a)	.039	.011	.005
February	.011	.045	NS	.016	.014	(a)	.010	.013
March	.019	.022	NS	.033	.040	.029	.023	.019
Strontium-90 concentration (pCi/liter)								
1966								
August	0.86	0.94	(a)	0.79	0.63	(a)	(a)	(a)
September	.67	1.00	(a)	.48	.58	3.59	NS	(a)
October	.75	.56	(a)	.30	.28	(a)	0.51	.62
November	(a)	.67	(a)	(a)	(a)	(a)	.40	2.23
December	2.14	2.48	NS	1.11	4.50	(a)	1.23	1.28
1967								
January	2.58	7.94	NS	4.02	(a)	26.2	4.18	4.00
February	1.13	1.75	NS	.71	1.51	(a)	1.19	1.36
March	1.58	1.41	NS	1.88	3.30	3.03	.76	1.68
Total plutonium deposition (pCi/m²)								
1966								
August	0.54	1.29	ND	4.26	1.53	0.56	0.36	(a)
September	1.80	1.66	ND	3.14	1.18	.47	NS	ND
October	1.16	.90	----------	.98	ND	(a)	.16	.27
November	.44	.57	(a)	.20	(a)	(a)	.42	ND
December	1.13	.58	NS	.95	.17	(a)	.31	.60
1967								
January	1.03	.44	NS	1.39	NS	.46	.37	.71
February	.90	1.81	NS	.57	.41	NS	1.03	.42
March	1.17	2.13	NS	1.01	.87	.49	3.85	1.31
Strontium-90 deposition (pCi/m²)								
1966								
August	38	38	(a)	205	64	(a)	(a)	(a)
September	68	46	(a)	112	59	151	NS	(a)
October	72	26	(a)	24	7	(a)	9	25
November	(a)	31	(a)	(a)	(a)	(a)	22	210
December	108	177	NS	153	92	(a)	86	189
1967								
January	178	255	NS	356	NS	312	138	600
February	91	70	NS	24	45	NS	122	42
March	96	136	NS	58	72	52	127	117

[a] Insufficient sample. Analysis was not done because the volume of sample available was not large enough to justify the work. In a number of cases, there was sufficient sample to do the plutonium analysis, but not enough to do both.

ND, nondetectable. An analysis was performed but the amount of radioactivity present was below the limit of detectability, defined as the count which will be exceeded 5 percent of the time by a sample containing no radioactivity (*6*). In the case of the plutonium analyses, 1,000 minute counts were used, "ND" is equivalent to 0.035 pCi in the total sample. In general, a 5-liter sample is used so specific activity of less than 0.007 pCi/liter would not be detected. Those samples reported at less than 0.007 pCi/liter were larger than 5 liters. ND is not used in connection with strontium-90 in this report.

NS, no sample received.

total radioactivity is the sum of the result for both aliquots. The chemical yield of the analytical procedure is approximately 80 percent as determined by reference samples. The samples are counted for 1,000 minutes in a 2-inch diameter, 0.080 mg/cm^2 window proportional counter.

The counting error at the 95-percent confidence level is less than 10 percent for most of the samples and the volume of the sample is known. The precision of the analytical procedure is estimated to be approximately 20 percent of the 1 pCi/liter level.

Table 1 gives the results of analysis for August 1966 through March 1967. The basic finding is the concentration (pCi/liter). This figure is multiplied by the depth of precipitation for the month (mm) to obtain the total deposition (pCi/m^2).

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SECTION I. MILK AND FOOD

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Both Federal and State agencies are involved in efforts to monitor continuously the dietary intake of radionuclides. The most direct measure of radionuclide intake would be obtained through radioanalysis of the total diet. Difficulties in obtaining specific dietary data impede this approach. An alternate method entails the use of indicator foods to arrive at an estimate of the total dietary radionuclide intake.

Fresh milk is one such indicator food. It is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides which appear in the diet. It also is one of the major sources of dietary intake for the short-lived radionuclides. For these reasons, fresh milk is the single food item most often used in estimating the intake of selected radionuclides by the general population and/or specific population groups. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of fresh milk.

The Federal Radiation Council (FRC) has developed Radiation Protection Guides (RPG's) for controlling normal peacetime nuclear operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the FRC Protective Action Guides (*4*) and by the International Commission on Radiological Protection (*5,6*).

Data from selected national, international, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross-section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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National and International Milk Surveillance

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various national and international organizations routinely monitor radionuclide levels in milk. In addition to those programs reported below, *Radiological Health Data and Reports* coverage includes:

Program	Period reported	Last presented
Radiostrontium in milk, HASL	July–December 1966	September 1967

1. Pasteurized Milk Network June 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

The Public Health Service's Pasteurized Milk Network (PMN), was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 stations (figure 1) provides data on milk in every State, the Canal Zone, and Puerto Rico. The most recent de-

Table 1. Analytical errors associated with determinations of radionuclide concentrations in milk

Nuclide	Concentration (pCi/liter)	Error [a] (pCi/liter)	Concentration (pCi/liter)	Error [a] (percent of concentration)
Strontium-89	<50	5	≥ 50	10
Strontium-90	<20	2	≥ 20	10
Iodine-131	<100	10	≥100	10
Cesium-137	<100	10	≥100	10
Barium-140	<100	10	≥100	10

[a] Two standard deviations.

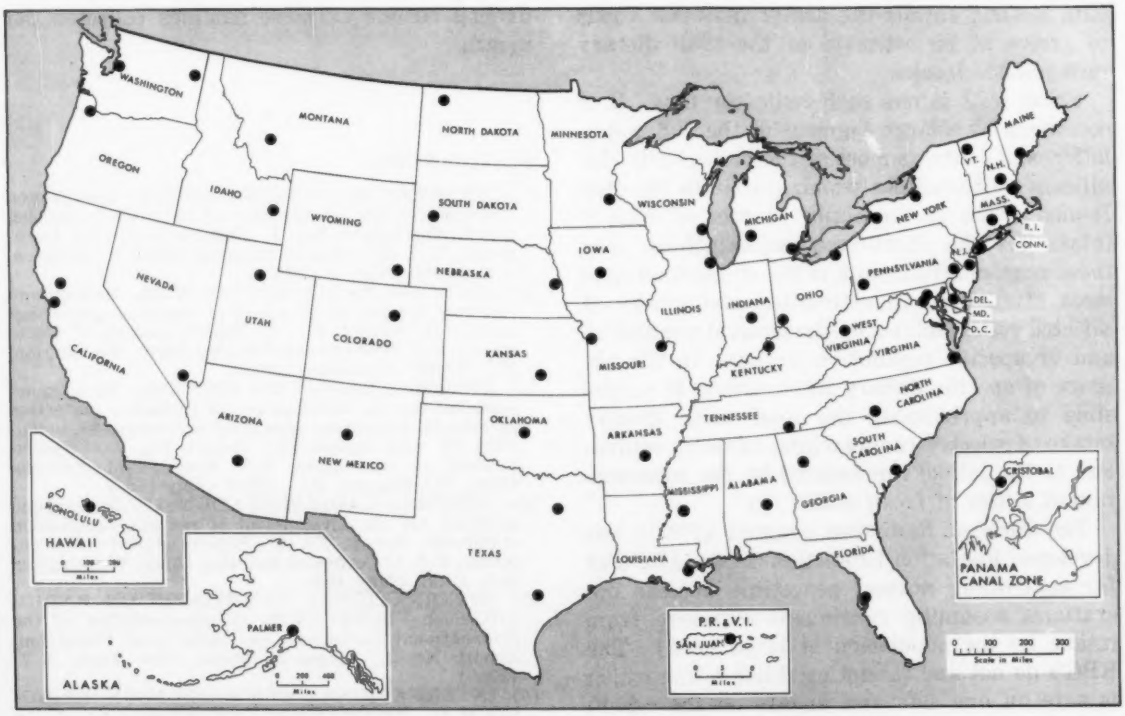

Figure 1. Pasteurized Milk Network sampling stations

Table 2. Average concentration of radionuclides in pasteurized milk for the second quarter 1967 and June 1967 [a]

Sampling location		Concentrations (pCi/liter)					
		Strontium-89 [b]		Strontium-90		Cesium-137	
		Second quarter 1967	June 1967	Second quarter 1967	June 1967	Second quarter 1967	June 1967
Ala:	Montgomery	< 5	< 5	10	8	15	15
Alaska:	Palmer	< 5	< 5	7	7	20	15
Ariz:	Phoenix	< 5	< 5	4	2	< 5	< 5
Ark:	Little Rock	< 5	< 5	27	25	20	25
Calif:	Sacramento	10	< 5	5	7	10	5
	San Francisco	10	5	5	5	10	5
C. Z:	Cristobal	< 5	< 5	5	4	30	15
Colo:	Denver	< 5	< 5	6	9	10	10
Conn:	Hartford			9	9	20	20
Del:	Wilmington			12	12	15	15
D. C:	Washington	< 5	< 5	10	10	15	10
Fla:	Tampa	< 5	< 5	9	8	75	80
Ga:	Atlanta	< 5	< 5	17	17	25	25
Hawaii:	Honolulu	< 5	< 5	4	3	10	10
Idaho:	Idaho Falls	< 5	< 5	7	7	10	10
Ill:	Chicago	< 5	< 5	10	8	15	10
Ind:	Indianapolis			10	9	15	10
Iowa:	Des Moines	< 5	< 5	9	9	15	10
Kans:	Wichita	< 5	< 5	8	10	10	< 5
Ky:	Louisville	< 5	< 5	15	15	10	10
La:	New Orleans	< 5	< 5	28	27	30	35
Maine:	Portland			12	13	35	40
Md:	Baltimore	< 5	< 5	13	13	20	20
Mass:	Boston	< 5	< 5	12	13	35	35
Mich:	Detroit			9	9	15	15
	Grand Rapids			11	11	25	20
Minn:	Minneapolis	< 5	< 5	14	15	20	15
Miss:	Jackson	< 5	< 5	21	18	20	20
Mo:	Kansas City	5	< 5	10	12	10	10
	St. Louis	5	5	10	9	10	5
Mont:	Helena	< 5	< 5	6	6	10	10
Nebr:	Omaha	< 5	< 5	8	10	10	10
Nev:	Las Vegas	< 5	< 5	2	3	5	5
N. H:	Manchester			15	17	50	55
N. J:	Trenton			10	11	20	15
N. Mex:	Albuquerque	< 5	< 5	3	3	< 5	< 5
N. Y:	Buffalo			9	9	20	15
	New York City			12	11	20	20
	Syracuse			9	9	20	15
N. C:	Charlotte	< 5	< 5	19	18	20	20
N. Dak:	Minot	5	5	17	13	25	15
Ohio:	Cincinnati			11	11	15	10
	Cleveland			11	11	20	15
Okla:	Oklahoma City	< 5	< 5	12	13	10	10
Oreg:	Portland	5	10	10	9	20	20
Pa:	Philadelphia			10	11	15	15
	Pittsburgh			15	15	25	20
P. R:	San Juan	< 5	< 5	4	5	15	15
R. I:	Providence			11	11	25	30
S. C:	Charleston	< 5	< 5	16	15	35	40
S. Dak:	Rapid City	5	< 5	14	17	15	15
Tenn:	Chattanooga	< 5	< 5	17	17	20	20
	Memphis	< 5	< 5	16	16	10	15
Tex:	Austin	< 5	< 5	4	4	10	10
	Dallas	< 5	< 5	12	13	15	10
Utah:	Salt Lake City	< 5	< 5	6	7	15	15
Vt:	Burlington			11	11	25	20
Va:	Norfolk	< 5	< 5	14	15	15	15
Wash:	Seattle	5	5	12	11	35	30
	Spokane	< 5	< 5	12	13	20	20
W. Va:	Charleston	< 5	< 5	15	16	15	15
Wis:	Milwaukee			7	7	20	15
Wyo:	Laramie	< 5	< 5	5	7	10	10
Network average		< 5	< 5	10.9	10.9	20	20

[a] Iodine-131 and barium-140 concentrations for all stations were below the limits of detectability.
[b] Blank indicates no strontium-89 determinations were made on samples from station during month.

scription of the sampling and analytical procedures employed by the PMN appeared in the December 1966 issue of *Radiological Health Data and Reports* (*1*).

Table 1 shows the approximate analytical errors (including counting error) associated with determinations of radionuclide concentrations in milk. These errors were determined by comparing results of a large number of replicate analyses. The results for June 1967 and the second quarter of 1967 are presented in table 2. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable values; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 3 and 4 for June 1966 and January through June 1967. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

Table 3. Frequency distribution, strontium-90 concentrations in milk at PMN stations June 1966, January–June 1967

Strontium-90 (pCi/liter)	Number of stations						
	1966	1967					
	June	Jan	Feb	Mar	Apr	May	June
Under 10	9	24	21	25	25	25	27
10–19	41	36	38	35	34	35	34
20–29	10	3	4	2	4	3	2
30–39	3	0	0	1	0	0	0

Table 4. Frequency distribution, cesium-137 concentrations in milk at PMN stations, June 1966 January–June 1967

Cesium-137 (pCi/liter)	Number of stations						
	1966	1967					
	June	Jan	Feb	Mar	Apr	May	June
Under 50	56	62	62	62	62	61	61
50–99	6	1	1	1	1	2	2
100–149	1	0	0	0	0	0	0

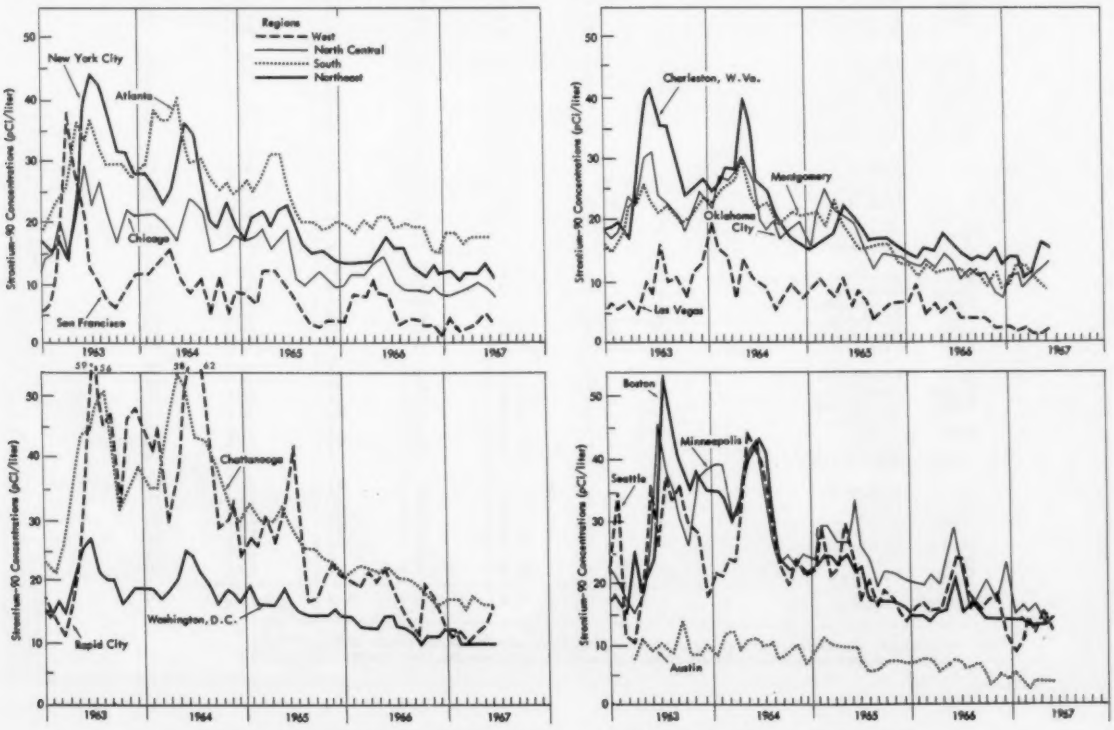

Figure 2. Strontium–90 concentrations in pasteurized milk, 1961–June 1967

2. Canadian Milk Network June 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present, 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for stontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1966 issue of *Radiological Health Data and Reports* (*2*).

The June 1967 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 5. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

[1] Prepared from July 1967 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 5. Stable elements and radionuclides in Canadian whole milk, June 1967

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.08	1.6	14	28
Edmonton	1.09	1.5	11	30
Ft. William	1.08	1.4	18	44
Fredericton	1.09	1.4	24	34
Halifax	1.10	1.6	21	36
Montreal	1.07	1.4	14	26
Ottawa	1.13	1.4	11	21
Quebec	1.08	1.4	17	57
Regina	NS	NS	NS	NS
St. John's, Nfld.	1.08	1.4	29	64
Saskatoon	1.09	1.5	12	26
Sault Ste. Marie	1.11	1.5	18	40
Toronto	1.13	1.6	8	24
Vancouver	1.15	1.5	22	74
Windsor	1.12	1.4	7	13
Winnipeg	1.18	1.6	11	14
Average	1.11	1.5	16	35

NS, no sample collected.

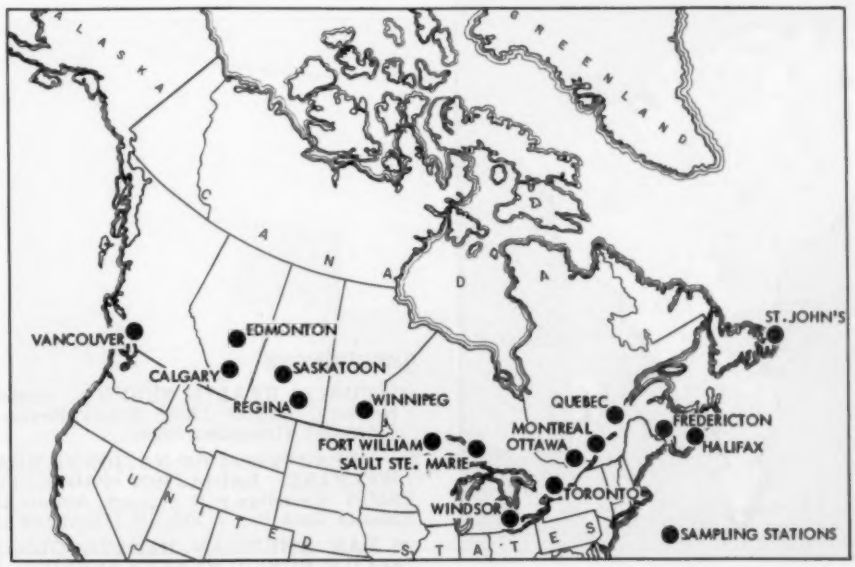

Figure 3. Canadian milk sampling stations

3. Pan American Milk Sampling Program June 1967

Pan American Health Organization and *U.S. Public Health Service*

The Pan American Health Organization (PAHO), in collaboration with the U.S. Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1966 issue of *Radiological Health Data and Reports* (*3*).

Figure 4. Pan American Milk Sampling Program locations

Table 6 presents stable potassium, strontium–90, and cesium–137 monthly average concentrations for June 1967.

Table 6. Stable element and radionuclide concentration in PAHO milk, June 1967 [a]

Sampling station		Number of samples	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Chile:	Santiago	1	1.59	2	30
Colombia:	Bogota	1	1.59	3	5
Ecuador:	Guayaquil	1	1.47	< 1	< 5
Jamaica:	Kingston	NS			
	Mandeville	NS			
	Montego Bay	1	1.37	12	235
Venezuela:	Caracas				
	April 1967	1	1.52	2	10
	May 1967	1	1.26	3	10
	June 1967	1	1.71	3	10
Canal Zone:	Cristobal [b]	4	----------	4	15
Puerto Rico:	San Juan [b]	4	----------	5	15

[a] Iodine-131 and barium-140 determinations were less than 10 pCi/liter for all samples. Strontium-89 was less than 5 pCi/liter for all samples.

[b] For comparison purposes, the radionuclide concentrations at Cristobal, Canal Zone and San Juan, Puerto Rico, from the Pasteurized Milk Network, are presented.

NS, no sample collected.

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(*3*) PAN AMERICAN HEALTH ORGANIZATION and U.S. PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1966. Radiol Health Data Rep 7:704–705 (December 1966).

State Milk Surveillance Activities

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have reached a point of having comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes. The results presented herein are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Figure 1 shows the States which report milk surveillance activities in *Radiological Health Data and Reports*. States having programs appearing in the current issue are highlighted in the figure. A summary of State programs previously covered, the reporting period, and issue of appearance are as follows.

State milk network	Period covered	Last presented
California	January–March 1967	September 1967
Connecticut	January–March 1967	August 1967
Indiana	January–March 1967	August 1967
Iowa	January–March 1967	August 1967
Michigan	January–March 1967	August 1967
Minnesota	January–March 1967	August 1967
New York	January–March 1967	August 1967
Oklahoma	January–March 1967	July 1967
Oregon	January–March 1967	September 1967
Pennsylvania	January–March 1967	August 1967
Washington	January–March 1967	September 1967

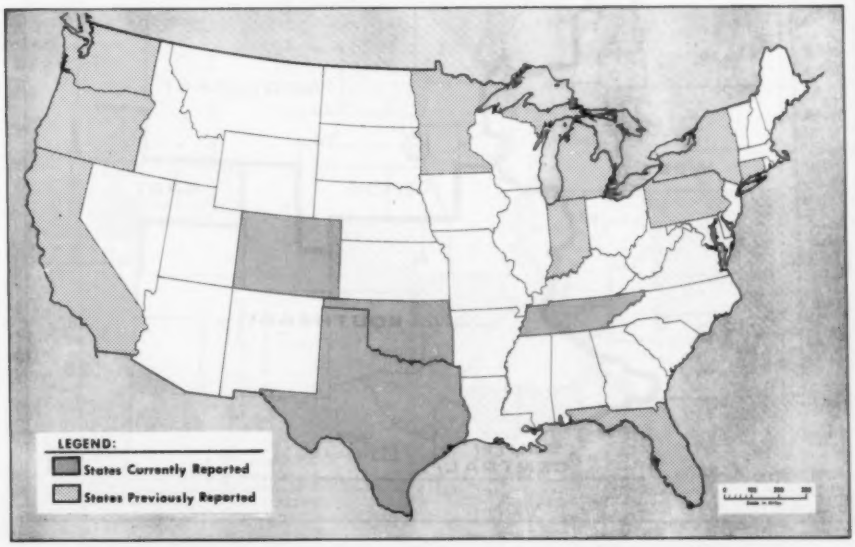

Figure 1. Reported State milk programs

1. Colorado Milk Network April–June 1967

Occupational and Radiological Health Division
Colorado State Department of Public Health

The Radiological Health Division of the Colorado State Department of Public Health initiated radiological analysis of milk in January 1962. Initially, the Denver City and County Health Department collected a weekly composite milk sample from the major producers in the Denver area for the State, as it had for the Public Health Service since March 1960.

In August 1962, the State expanded its program to include the routine sampling of raw milk from the four major milk producing areas supplying the State; northeast, southeast, west Colorado, and east Utah. Areas presently sampled are the west, south central, northeast and east Colorado (including northwest Kansas). Colorado milkshed areas are shown in figure 2.

Analyses are performed for iodine–131, barium–140, cesium–137, and potassium by gamma-ray spectroscopy. The measurement system previously reported (*1*) has been adapted to utilize a 4- by 5-inch NaI crystal shielded by a leadlined bank safe.

Minimum detectable amounts at the 2 standard deviation counting-error equivalent are: iodine–131, 10 pCi/liter; cesium–137 and barium–lanthanum–140, 15 pCi/liter; and potassium, 0.2 g/liter.

Barium–lanthanum–140, iodine–131 and potassium were not detected during the period April–June 1967. On June 13, one of four samples collected in northeastern Colorado showed a concentration of 29 pCi/liter of cesium–137.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
May 1965–June 1966	October 1966
January–March 1967	July 1967

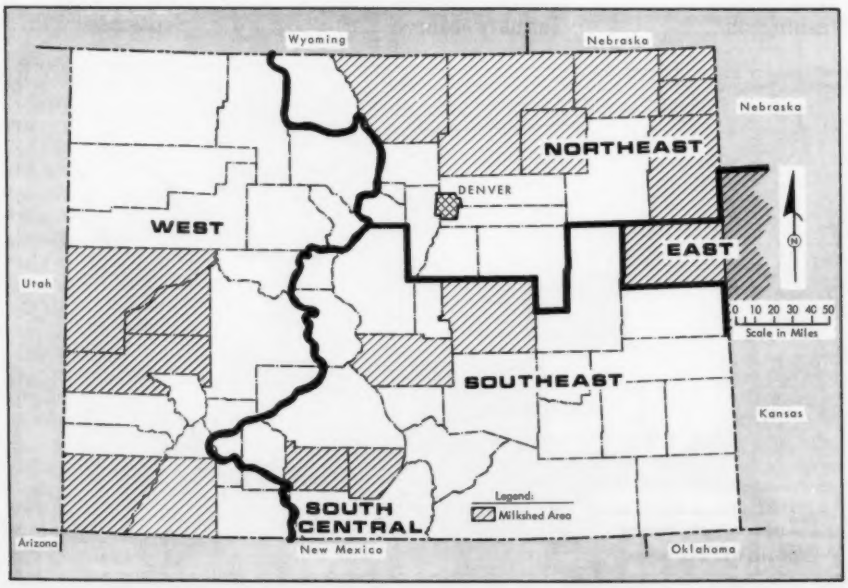

Figure 2. Colorado milk sampling areas

2. Florida Milk Network Summary 1966 and January–June 1967

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine–131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of milk for strontium–89, strontium–90, cesium–137, barium–140 and potassium, in addition to iodine–131. Monthly samples are taken from randomly selected farms in each of the six regions shown in figure 3. A regional State Board of Health Laboratory is located in each of the six regions referred to in this report. Each laboratory prepares a monthly composite milk sample for its region by combining samples from 10 percent of the dairy farms selected at random. These composite samples are then sent to the State Radiological Health Laboratory in Orlando for analysis. In the interest of maintaining an active standby capability, samples are also collected and analyzed for iodine–131 on a monthly basis using the resin cartridge technique. Milk produced in the counties comprising each area is generally processed, marketed, and consumed in that area. These areas are characteried by differences in dairying practices related to the gradual transition from small farms in the west Florida region, where locally grown feeds are used, to larger farms in the southern areas, where different types of grass and predominantly purchased feeds are used.

Strontium–89 and strontium–90 are determined by the ion exchange method developed by Porter, *et al* (*2*). Iodine–131, cesium–137, barium–140 and potassium are determined by gamma-ray spectrometry (*3*).

Radionuclide concentration levels for January through March 1967, are presented in table 1 and April through June 1967 are pre-

Figure 3. Florida milk sampling areas

Table 1. Stable element and radionuclide concentrations in Florida raw milk, January–March 1967

Sampling location in Florida	Potassium (g/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar	Jan	Feb	Mar
West	1.30	1.39	1.31	NA	27	NA	ND	<10	ND	50	20	27	ND	<10	ND
North	1.50	1.26	1.47	NA	21	NA	ND	<10	ND	33	21	42	ND	19	ND
Northeast	1.65	1.50	1.48	NA	14	NA	ND	<10	ND	109	95	87	ND	<10	ND
Central	1.47	1.15	1.32	NA	13	NA	ND	<10	ND	91	65	76	ND	<10	ND
Tampa Bay area	1.39	1.65	1.48	NA	21	NA	ND	<10	ND	104	95	107	ND	12	ND
Southeast	1.55	1.34	1.48	NA	9	NA	ND	<10	ND	111	77	104	ND	<10	ND
Average	1.48	1.40	1.45	------	17	------	------	[a] 10	------	83	62	74	------	[a] 12	

[a] <10 averaged as 10.
NA, no analysis.
ND, none detected.

Table 2. Stable element and radionuclide concentrations in Florida raw milk, April–June 1967

Sampling location in Florida	Potassium (g/liter)			Strontium-90 (pCi/liter)			Iodine-131 (pCi/liter)			Cesium-137 (pCi/liter)			Barium-140 (pCi/liter)		
	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun	Apr	May	Jun
West	1.48	1.59	1.59	NA	22	19	ND	ND	ND	26	21	47	ND	ND	26
North	NS	1.49	1.43	NS	19	21	NS	ND	ND	NS	49	49	NS	ND	ND
Northeast	1.33	1.54	1.58	NA	14	7	ND	ND	ND	117	112	107	NS	ND	ND
Central	1.41	1.67	1.63	NA	8	9	ND	ND	ND	106	75	106	NS	ND	ND
Tampa Bay area	1.52	1.42	1.61	NA	9	10	ND	ND	30	112	89	117	NS	ND	ND
Southeast	1.42	1.54	1.51	NA	NA	10	ND	ND	ND	104	63	85	NS	ND	ND
Average	1.43	1.54	1.56	------	14	13	------	------	<10	93	68	85	------	------	<10

NA, no analysis.
ND, none detected.
NS, no sample.

sented in table 2. Strontium–89 analyses have been discontinued since 1965 due to extremely low levels. Table 3 provides a summary of average monthly concentrations during the calendar year 1966.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–March 1966	July 1966
April–June 1966	October 1966

Table 3. Monthly average radionuclide concentrations in Florida raw milk, calendar year 1966 [a]

Month 1966	Radionuclide concentration (pCi/liter)		
	Strontium-90	Iodine-131	Cesium-137
January	17	ND	89
February	17	ND	95
March	17	ND	89
April	16	<10	91
May	15	<10	90
June	17	<30	95
July	13	<30	95
August	12	<10	148
September	13	<10	144
October	NA	<10	133
November	NA	<10	107
December	NA	<10	108

[a] <10 averaged as 10.
ND, none detected.
NA, no analysis.

3. Oklahoma Milk Network April–June 1967

Oklahoma State Department of Health [1]

On March 15, 1965, the Radiological Health Section of the Oklahoma State Department of Health initiated a program of analysis for iodine–131 in the milk produced in the State of Oklahoma. On March 7, 1966, analysis for cesium–137 was added to the program.

The location of the sampling stations and the extent of their associated milksheds are shown in figure 4. Of the 10 milksheds in the State of Oklahoma, 5 were chosen as sampling stations (Oklahoma City, Enid, Tulsa, Lawton, and Ardmore) on the basis of their size and location. A major criterion in the selection of a milkshed for sampling was the degree of overlap with other milksheds being sampled. This overlap assists in locating small areas of production where the concentration of radioactivity might be abnormally high.

The sampling stations are located in the laboratory of a major milk-processing plant in each milkshed. While the milkshed for a particular processing plant may not coincide exactly with that shown in figure 4, the coincidence is satisfactory for surveillance purposes.

At the present time, samples are collected on Monday morning, and the analyses are completed by Wednesday afternoon. However, if iodine–131 or cesium–137 levels detected are such that diversion of the milk or other precautionary methods need to be taken, the analytical method and equipment can be employed to sample each truck arriving at the processing plant. Under these conditions, only about 4 hours would be needed to complete the analysis. This greatly reduced lag time for analysis would permit rapid decisions on the fate of each truckload of raw milk.

Analytical method

The method of analysis is similar to that recently published by the U.S. Public Health Service (4) but was developed independently

[1] Acknowledgement is accorded to the staff of the Radiological Health Section under the direction of Mr. Dale McHard, head, and Mr. Robert Craig, assistant engineer.

Table 4. Concentration of cesium-137 in Oklahoma pasteurized milk, April–June 1967

(pCi/liter)

Sampling date	Sampling location				
	Oklahoma City	Enid	Tulsa	Lawton	Ardmore
April 7	ND	12	13	9	ND
14	16	17	14	10	10
21	ND	44	42	10	41
28	NS	NS	NS	NS	NS
May 5	NS	NS	NS	NS	NS
12	NS	NS	NS	NS	NS
19	ND	ND	ND	ND	17
26	ND	ND	ND	ND	ND
June 2	36	ND	21	ND	NS
9	ND	ND	12	ND	ND
16	ND	ND	ND	ND	ND
26	ND	ND	ND	ND	NS
30	ND	NS	ND	ND	ND

ND, non detectable—less than 3 pCi/liter.
NS, no sample collected.

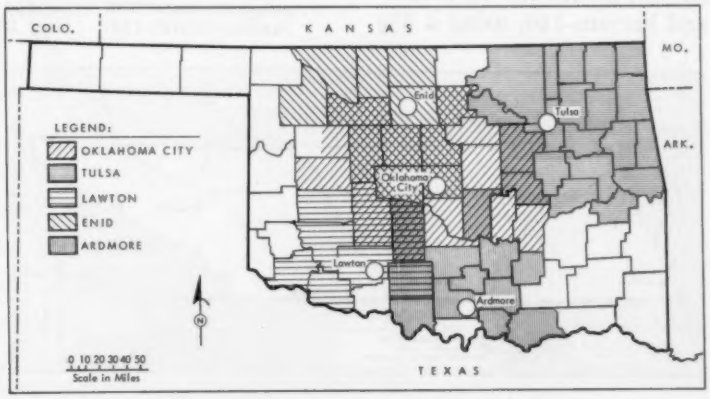

Figure 4. Oklahoma milkshed sampling areas

by the Oklahoma State Health Department's Radiological Health Laboratory and has not been published to date. Details of the procedure used were published earlier (*5*).

Results and discussion

Concentrations of iodine–131 found in Oklahoma milk samples collected from April through June 1967 were below detectable concentrations of 3 pCi/liter except for one sample collected on April 21, 1967, at Lawton that contained 7 pCi/liter. Cesium–137 concentrations are presented in table 4.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966	April 1967
January–March 1967	July 1967

4. Tennessee Milk Network April–June 1967

Division of Preventable Diseases
Department of Public Health,
State of Tennessee

The Tennessee Department of Public Health began sampling pasteurized milk for radionuclide analysis in July of 1965. Currently the Department is collecting semimonthly milk samples from three cities (figure 5). In order to obtain a representative sample of the milk consumed in the areas monitored, a sample of milk is collected from each milk distributor supplying the city. The samples from the individual distributors are then composited in proportion to the contribution each makes to the total city milk supply.

Analytical procedures

The semimonthly milk samples from each city sampled are analyzed by gamma-ray scintillation spectrometry for potassium–40, iodine–131, cesium–137, and barium–140, using a 3½ liter sample. After gamma-ray analysis, the samples are stored for 2 weeks to allow ingrowth of daughter radioactivity, after which strontium–89, strontium–90, and barium–140 concentrations are determined radiochemically using ion-exchange procedures. Chemical analyses are also made for stable calcium and potassium.

It should be noted that the Chattanooga milk sample is monitored by both the State and the Public Health Service's Southeastern Radiological Health Laboratory. This dual examination of an aliquoted sample provides a cross check between the two laboratories.

Results

The monthly average stable element and radionuclide concentrations in Tennessee pasteurized milk are presented in table 5 for the period of April through June 1967.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July 1965–June 1966	April 1967
January–March 1967	July 1967

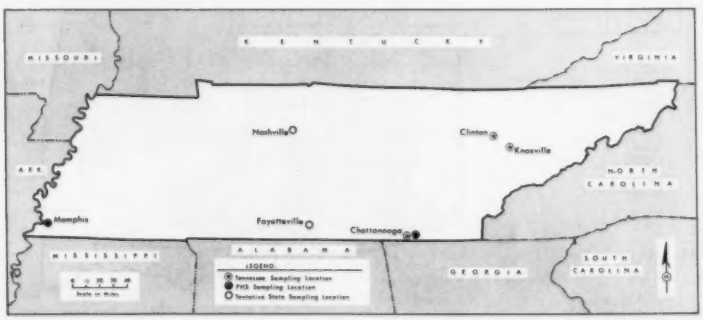

Figure 5. Tennessee pasteurized milk sampling stations

Table 5. Radionuclides in Tennessee pasteurized milk, April–June 1967

Location	Month 1967	Concentration (g/liter)	Radionuclide concentration (pCi/liter)				
		Potassium	Strontium-89	Strontium-90	Iodine-131	Cesium-137	Barium-140
Chattanooga	April	1.3	7	17	< 8	23	<5
	May	1.4	<5	27	17	25	<5
	June	1.4	<5	26	11	23	<5
Clinton	April	1.4	<5	18	25	22	<5
	May	1.4	<5	24	< 8	29	<5
	June	1.4	<5	29	< 8	23	<5
Knoxville	April	1.4	<5	16	15	16	<5
	May	1.5	<5	16	8	26	<5
	June	1.4	<5	18	< 8	23	<5

5. Texas Milk Network April–June 1967

Texas State Department of Health [2]

The Texas State Department of Health initiated a statewide milk sampling network for radionuclide content in April 1964. At present, monthly samples of raw milk are collected from each of seven "active" sampling points. In addition, six "standby" stations are collecting raw milk samples once each calendar quarter. The station locations shown in figure 6 were chosen to give maximum geographical and population coverage.

Samples are routinely analyzed for strontium–90 by a chemical separation technique employing ion exchange columns (*6*). Prepared samples are counted for 100 minutes in a low-background beta-particle counter.

[2] Acknowledgement is accorded to the staff of the Radiation Control Program, Division of Occupational Health and Radiation Control, under the direction of Mr. Martin C. Wukasch, chief engineer.

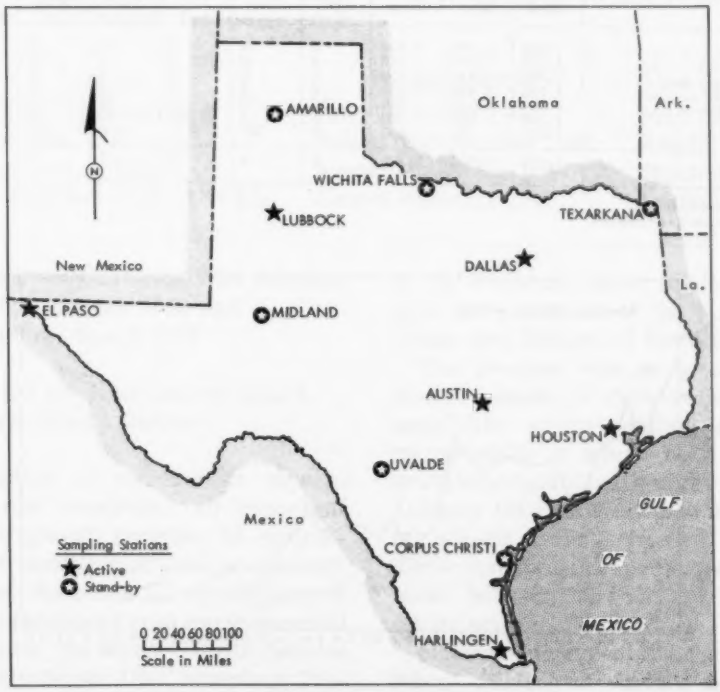

Figure 6. Texas milk sampling stations

Potassium–40, iodine–131, barium–140, and cesium–137 concentrations are determined by gamma-ray spectrometry. The procedure employs a 4- by 4-inch sodium-iodide crystal and a 400-channel analyzer. Samples are counted for 100 minutes in a 3.5 liter Marinelli beaker. The matrix method of calculation is used and detection limits at the 95-percent confidence level are 10 pCi/liter.

Results

Potassium–40, strontium–90 and cesium–137 results by station and month for April through June 1967, are presented in table 6. During this time, the iodine–131 and barium–140 concentrations were below their limits of detectability (10 pCi/liter). A summary of radionuclide concentrations in Texas milk for the period from April 1964 through June 1967, is presented in figure 7.

Comparison of the observed radionuclide concentrations with the Federal Radiation Council guides for peacetime operations indicates that at no time during the period of surveillance did the radionuclide concentrations in Texas milk approach levels suggesting any remedial action (*7*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1966 and annual summary 1966	April 1967
January–March 1967	July 1967

Table 6. Radionuclide concentrations in Texas raw milk network, April–June 1967

Sampling location	Radionuclide concentration (pCi/liter)								
	Potassium-40			Strontium-90			Cesium-137		
	April	May	June	April	May	June	April	May	June
Austin	1,290	1,260	1,400	5	4	4	6	5	3
Fort Worth	1,270	1,370	1,310	8	9	4	5	ND	ND
El Paso	1,310	1,310	1,350	3	2	2	5	5	5
Harlingen	1,270	1,290	1,280	3	2	2	5	5	ND
Houston	1,360	1,370	1,350	10	10	8	15	20	15
Lubbock	1,290	1,350	NS	5	5	NS	10	5	NS
San Antonio	1,360	NS	1,330	4	NS	5	5	NS	ND
Average	1,310	1,330	1,370	5	5	4	7	7	4

ND, nondetectable.
NS, no sample collected.

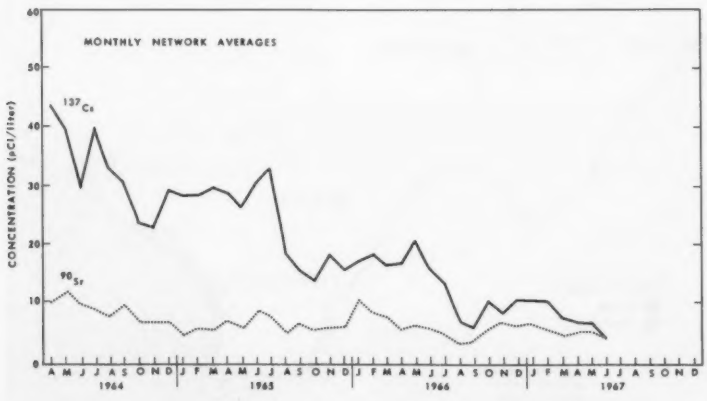

Figure 7. Radionuclide concentrations in Texas milk, April 1964–June 1967

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(2) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium–90 in milk by ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(3) FLORIDA STATE BOARD OF HEALTH, DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH. Florida milk network, July–December 1964. Radiol Health Data 6:611–612 (November 1965).

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(6) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by ion exchange method. Anal Chem 36:676–678 (March 1964).

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Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Periodically, results from the United Kingdom Diet Survey, conducted by the United Kingdom Agricultural Research Council Radiobiological Laboratory, are presented for comparison with data observed in the United States. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Last presented
Connecticut Standard Diet	July–December 1966	May 1967
Teenage Diet, FDA	February–November 1965	August 1966
Tri-City Diet, HASL	August–December 1966	September 1967
United Kingdom Diet, ARCRL	Annual summary 1965	December 1966

1. Radionuclides in Institutional Diet Samples Annual Summary 1966 and January–March 1967

National Center for Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is administered by the National Center for Radiological Health with the assistance of the National Center for Urban and Industrial Health (1).

The program was designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be

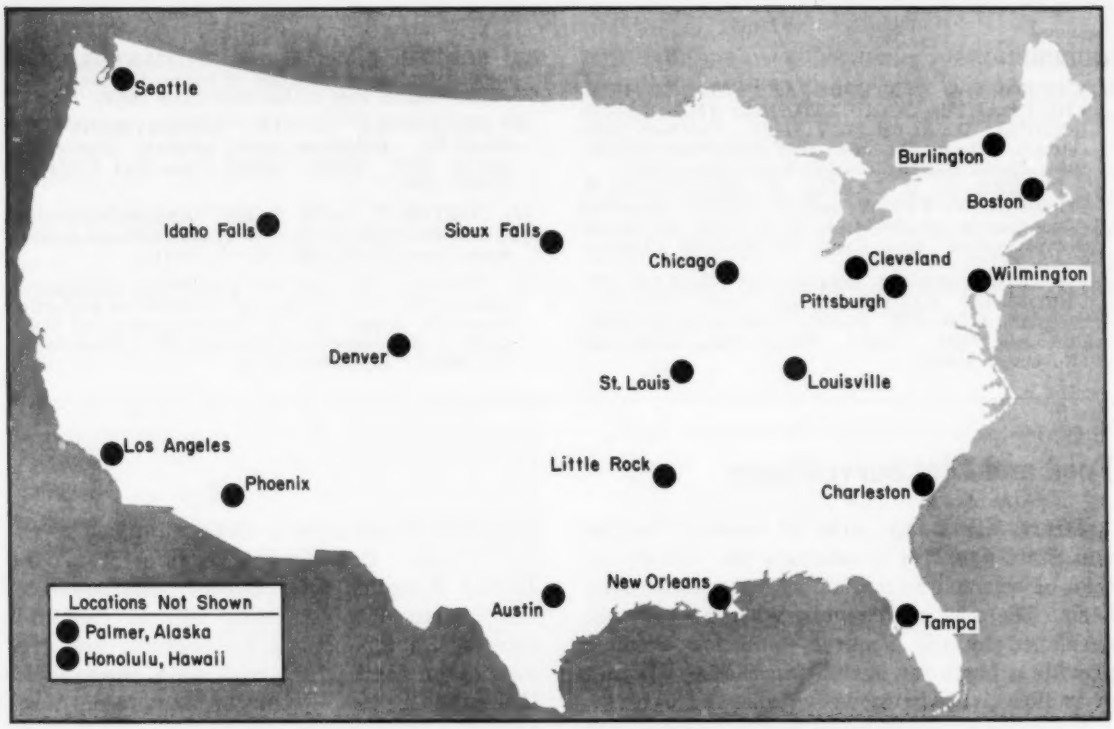

Figure 1. Institutional diet sampling locations as of July 1965

selectively reduced. As of July 1965, 21 institutions, distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily intake of teenage girls and children from 9 to 12 years of age were comparable while teenage boys consumed 20 percent more food per day (*1,2*). Consequently, estimates for teenage boys and/or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample supplied monthly by each institution represents the edible portion of the diet for a full 7-day week (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nev., Southeastern Radiological Health Laboratory, Montgomery, Ala.; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented elsewhere (*3*).

Results

Table 1 presents the analytical results for institutional diet samples collected from January through March 1967, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of strontium–89, strontium–90, cesium–137, and radium–226 are expressed as pCi/kg of diet. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period, where applicable.

Dietary intakes, presented in table 2, were obtained by multiplying the food consumption rate in kg/day by the concentration values given in table 1. For the purpose of obtaining

Table 1. Stable elements and radionuclide concentrations in institutional total diets of children, January–March 1967

Location of institution		Month 1967	Stable elements (g/kg of diet)		Radionuclide concentrations (pCi/kg of diet)			
			Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Alaska:	Palmer	Jan	0.4	1.1	<5	8	20	0.4
		Feb	.7	1.1	<5	13	25	.8
		Mar	.3	1.4	5	13	45	.6
Ariz:	Phoenix	Jan	.7	1.1	<5	6	10	.6
		Feb	.6	1.1	<5	5	< 5	.6
		Mar	.5	1.7	<5	3	< 5	.4
Ark:	Little Rock	Jan	.7	1.7	NA	13	20	.8
		Feb	.6	1.6	NA	13	15	1.0
		Mar	.6	1.4	NA	13	20	1.2
Calif:	Los Angeles	Jan	1.1	1.4	5	5	15	.6
		Feb	.8	1.6	<5	5	20	.6
		Mar	.8	1.7	<5	4	10	.5
Colo:	Denver	Jan	.7	1.2	<5	7	25	.5
		Feb	.6	1.3	<5	8	< 5	.5
		Mar	.7	1.8	<5	8	15	.6
Del:	Wilmington	Jan	.7	1.8	<5	10	15	.7
		Feb	.7	1.8	<5	9	25	.6
		Mar	.7	1.9	<5	10	20	.6
Fla:	Tampa	Jan	.6	1.7	NA	9	35	1.0
		Feb	.6	1.6	NA	6	35	1.3
		Mar	.6	2.0	NA	8	40	1.3
Hawaii:	Honolulu	Jan	.4	1.0	<5	3	25	.5
		Feb	.5	1.3	<5	4	20	.3
		Mar	.3	1.3	<5	3	20	.6
Idaho:	Idaho Falls	Jan	1.0	1.8	<5	11	30	.5
		Feb	.7	2.0	<5	11	25	.5
		Mar	.9	1.9	<5	8	10	.5
Ill:	Chicago	Jan	.7	1.7	<5	7	15	.7
		Feb	.8	1.6	<5	7	20	.8
		Mar	.8	1.8	<5	7	20	.5
Ky:	Louisville	Jan	.7	1.8	NA	9	20	4.6
		Feb	.8	1.6	NA	10	15	1.2
		Mar	.7	1.6	NA	12	15	1.0
La:	New Orleans	Jan	.7	1.8	<5	13	25	.9
		Feb	.6	1.5	<5	13	10	.8
		Mar	.7	1.7	<5	17	20	1.0
Mass:	Boston	Jan	.7	1.8	<5	11	35	.4
		Feb	.8	1.6	<5	12	25	.5
		Mar	.7	1.4	<5	10	30	.4
Mo:	St. Louis	Jan	.9	1.8	<5	10	20	.6
		Feb	.9	1.5	<5	11	15	1.0
		Mar	.9	1.6	<5	11	25	.6
Ohio:	Cleveland	Jan	.8	1.7	<5	9	25	.8
		Feb	.6	2.0	<5	7	15	.6
		Mar	.7	1.8	<5	8	25	.6
Pa:	Pittsburgh	Jan	.6	1.6	<5	8	25	.7
		Feb	.6	1.5	<5	8	20	.8
		Mar	.6	1.3	<5	7	25	.5
S. C:	Charleston	Jan	.6	1.4	<5	13	25	1.2
		Feb	.7	1.4	<5	15	25	1.1
		Mar	.6	1.3	<5	12	20	2.9
S. Dak:	Sioux Falls	Jan	.7	1.6	<5	5	20	.8
		Feb	.7	1.6	<5	6	25	.7
		Mar	1.2	1.6	<5	17	20	1.5
Tex:	Austin	Jan	.6	1.5	NA	8	15	1.2
		Feb	.4	1.0	NA	6	5	1.0
		Mar	.6	1.4	NA	5	10	1.2
Vt:	Burlington	Jan	.7	2.0	<5	13	30	.9
		Feb	.7	1.9	<5	12	20	.5
		Mar	.9	1.6	<5	11	30	.5
Wash:	Seattle	Jan	.7	1.3	<5	8	45	.6
		Feb	.8	1.2	<5	10	20	.4
		Mar	.6	1.7	5	6	10	.6
Institutional average		Jan	0.7	1.6	<5	9	25	0.9
		Feb	.7	1.5	<5	9	20	.7
		Mar	.7	1.6	<5	9	20	.8

[a] Since iodine-131 and barium-130 were not detectable at most stations during the first quarter 1966, no provision was made for these nuclides in the table. The few exceptions are as follows: Iodine-131 was reported in January for New Orleans, 20 pCi/kg; and Phoenix, 23 pCi/kg. Barium-140 was reported for Palmer, Alaska, 17 pCi/kg; Denver, 12 pCi/kg; and Seattle, 31 pCi/kg. Barium-140 was also reported in February and March for Honolulu, 13 pCi/kg; and in March for Seattle, 11 pCi/kg.

NA, no analysis.

dietary intakes, "less than" 5 pCi/kg of strontium–89 was interpreted as 2.5 pCi/kg. The average food consumption rate during this period was 1.75 kg/day compared to the network average of 1.90 kg/day observed from 1961 through 1964 (*4*).

Strontium–90 dietary intake during this period averaged 16 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (FRC) (*5*). Cesium–137 intakes average 35 pCi/day during this period. Strontium–89, barium–140, and iodine–131 concentrations were generally below detectable levels.

Table 2. Intake of stable elements and radionuclides in institutional total diet for children (9 to 12 years of age), October–December 1966

Location of institution		Month 1967	Total weight (kg/day)	Stable element intake (g/day)		Radionuclide intake (pCi/day)			
				Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Alaska:	Palmer	Jan	1.83	0.7	2.0	5	15	35	0.7
		Feb	1.75	1.2	1.9	5	23	45	1.4
		Mar	1.56	.5	2.2	10	20	70	.9
Ariz:	Phoenix	Jan	1.52	1.1	1.7	5	10	15	1.0
		Feb	2.03	1.2	2.2	5	10	5	1.2
		Mar	2.21	1.1	3.8	5	7	5	.9
Ark:	Little Rock	Jan	1.19	.8	2.0	----------	15	25	1.0
		Feb	1.14	.7	1.8	----------	15	15	1.1
		Mar	1.28	.8	1.8	----------	17	25	1.5
Calif:	Los Angeles	Jan	2.18	2.4	3.1	10	11	35	1.3
		Feb	2.09	1.7	3.3	5	10	40	1.3
		Mar	1.97	1.6	3.3	5	8	20	1.0
Colo:	Denver	Jan	2.17	1.5	2.6	5	15	55	1.1
		Feb	2.06	1.2	2.7	5	16	5	1.0
		Mar	2.04	1.4	3.7	5	16	30	1.2
Del:	Wilmington	Jan	2.17	1.5	3.9	5	22	35	1.5
		Feb	2.23	1.6	4.0	5	20	55	1.3
		Mar	2.05	1.4	3.9	5	21	40	1.2
Fla:	Tampa	Jan	2.18	1.3	3.7	----------	20	75	2.2
		Feb	2.14	1.3	3.4	----------	13	75	2.8
		Mar	2.07	1.2	4.1	----------	17	85	2.7
Hawaii:	Honolulu	Jan [a]	2.09	.8	2.1	5	6	50	1.0
		Feb [b]	1.95	1.0	2.5	5	8	40	.6
		Mar	2.16	.6	2.8	5	6	45	1.3
Idaho:	Idaho Falls	Jan [a]	2.16	2.2	3.9	5	24	65	1.1
		Feb [b]	1.75	1.2	3.5	5	19	45	.9
		Mar [a]	2.09	1.9	4.0	5	17	20	1.0
Ill:	Chicago	Jan [a]	1.53	1.1	2.6	5	11	25	1.1
		Feb	1.55	1.2	2.5	5	11	30	1.2
		Mar	1.73	1.4	3.1	5	12	35	.9
Ky:	Louisville	Jan	1.24	.9	2.2	----------	11	25	5.7
		Feb	1.78	1.4	2.8	----------	18	25	2.1
		Mar [b]	1.68	1.2	2.7	----------	20	25	1.7
La:	New Orleans	Jan	1.42	1.0	2.6	5	18	35	1.3
		Feb	1.68	1.0	2.5	5	22	15	1.3
		Mar	1.92	1.3	3.3	5	33	40	1.9
Mass:	Boston	Jan	1.86	1.3	3.3	5	20	65	.7
		Feb	1.48	1.2	2.4	5	18	35	.7
		Mar	1.66	1.2	2.3	5	17	50	.7
Mo:	St. Louis	Jan	1.43	1.3	2.6	5	14	30	.9
		Feb	1.38	1.2	2.1	5	15	20	1.4
		Mar	1.52	1.4	2.4	5	17	40	.9
Ohio:	Cleveland	Jan	1.11	.9	1.9	5	10	30	.9
		Feb	1.37	.8	2.7	5	10	20	.8
		Mar [b]	1.41	1.0	2.5	5	11	35	.8
Pa:	Pittsburgh	Jan	2.06	1.2	3.3	5	16	50	1.4
		Feb	2.17	1.3	3.3	5	17	40	1.7
		Mar	2.25	1.4	2.9	5	16	55	1.1
S. C:	Charleston	Jan	1.62	1.0	2.3	5	21	40	1.9
		Feb	2.13	1.5	3.0	5	32	55	2.3
		Mar	1.43	.9	1.9	5	17	30	4.1
S. Dak:	Sioux Falls	Jan [c]	1.21	.8	1.9	5	6	25	1.0
		Feb	1.20	.8	1.9	5	7	30	.8
		Mar [c]	1.11	1.3	1.8	5	19	20	1.7
Tex:	Austin	Jan	1.66	1.0	2.5	----------	13	25	2.0
		Feb	1.56	.6	1.6	----------	9	10	1.6
		Mar	1.76	1.1	2.5	----------	9	20	2.1
Vt:	Burlington	Jan	1.33	.9	2.7	5	17	40	1.2
		Feb [a]	1.30	.9	2.5	5	16	25	.6
		Mar	1.19	1.1	1.9	5	13	35	.6
Wash:	Seattle	Jan [a]	1.94	1.4	2.5	5	16	85	1.2
		Feb [a]	1.72	1.4	2.1	5	17	35	.7
		Mar [a]	1.67	1.0	2.8	10	10	15	1.0
Institutional average		Jan	1.69	1.2	2.6	5	16	40	1.6
		Feb	1.75	1.2	2.6	5	16	30	1.4
		Mar	1.80	1.2	2.9	5	15	40	1.4

[a] Since food samples were collected from two or more children who were over 12 years of age, data for this month were not used in institutional average.
[b] Since food samples were collected from two or more children whose ages were unknown, data for this month were not used in institutional average.
[c] Since food samples were collected from two or more children who were less than 9 years of age, data for this month were not used in the institutional average.

Annual averages

Annual average radionuclide concentrations in 1966 institutional total diet samples are given in table 3. The corresponding annual average intakes are presented in table 4. During 1966 the annual average intake varied from 1.27 to 2.41 kg/day with a mean of 1.79 kg/day. The average intake for 1965 was 1.89 kg/day (*4*) and for the period 1961–1964, 1.90 kg/day (*5*). The lower value for 1966 is due to the fact that the earlier data were not limited to the intake of children 9–12 years of

Table 3. 1966 annual average concentrations of selected stable elements and radionuclides in institutional daily diets of school children [a]

Location of institution		Stable element (g/kg)		Radionuclide concentration (pCi/liter)			
		Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Alaska:	Palmer	0.7	1.2	5	19	45	1.0
Ariz:	Phoenix	.6	1.1	5	9	20	0.9
Ark:	Little Rock	.6	1.5	5	15	20	1.1
Calif:	Los Angeles	.9	1.4	5	8	20	1.4
Colo:	Denver	.8	1.3	5	10	20	.7
Del:	Wilmington	.7	1.6	5	10	30	.7
Fla:	Tampa	.6	1.6	5	11	65	1.8
Hawaii:	Honolulu	.5	1.2	5	4	30	.6
Idaho:	Idaho Falls	.9	1.5	5	11	30	.6
Ill:	Chicago	.7	1.5	5	8	30	.6
Ky:	Louisville	.8	1.7	5	13	25	1.7
La:	New Orleans	.7	1.6	5	17	30	.9
Mass:	Boston	.6	1.5	5	9	30	.5
Mo:	St. Louis	.8	1.6	5	11	30	.6
Ohio:	Cleveland	.6	1.7	5	8	35	.7
Pa:	Pittsburgh	.6	1.4	5	10	25	.7
S.C:	Charleston	.7	1.4	5	14	35	1.3
S. Dak:	Sioux Falls	.8	1.6	5	12	45	.7
Tex:	Austin	.5	1.2	5	7	15	1.3
Vt:	Burlington	.6	1.6	5	12	40	.6
Wash:	Seattle	.8	1.5	5	16	45	.6
Institutional average		0.7	1.5	5	11	30	0.9

[a] Since iodine-131 and barium-140 concentrations were not detectable at most stations during the year 1966, no provision was made for these nuclides in the table. The few exceptions are:
June 1966: 24 pCi/kg of iodine-131 was reported for Sioux Falls, S. Dak.
October 1966: 10 pCi/kg of iodine-131 was reported for Louisville, Ky.
December 1966: 10 pCi/kg of iodine-131 was reported for Phoenix, Ariz.; Palmer, Alaska; Tampa. Fla; and New Orleans, La.
December 1966: Barium-140 was reported in the following institutions; Palmer, Alaska, 13 pCi/kg; Los Angeles, Calif., 16 pCi/kg; and Austin, Tex., 12 pCi/kg.

Table 4. 1966 annual average intakes of selected stable elements and radionuclides in institutional daily diets of school children (9–12 years of age)

Location of institution		Total weight (kg/day)	Stable element (g/day)		Radionuclide concentrations (pCi/day)			
			Calcium	Potassium	^{89}Sr	^{90}Sr	^{137}Cs	^{226}Ra
Alaska:	Palmer [a]	1.66	1.1	2.1	5	32	75	1.5
Ariz:	Phoenix [a]	1.90	1.2	2.2	5	17	35	1.9
Ark:	Little Rock	1.54	0.9	2.3	5	23	30	1.7
Calif:	Los Angeles [a]	1.99	1.7	2.8	5	15	40	2.8
Colo:	Denver [a]	2.18	1.6	2.7	5	22	45	1.4
Del:	Wilmington [c]	2.00	1.4	3.3	5	20	60	1.4
Fla:	Tampa [a]	1.97	1.4	3.1	5	22	140	3.5
Hawaii:	Honolulu [a]	2.05	1.0	2.5	5	10	65	1.1
Idaho:	Idaho Falls [b]							
Ill:	Chicago [a]	1.38	1.0	2.0	5	10	40	0.9
Ky:	Louisville [a] [c]	1.30	1.2	2.3	5	17	40	2.4
La:	New Orleans [a]	1.76	1.3	2.8	5	32	60	1.2
Mass:	Boston [a]	2.07	1.2	3.1	5	17	65	1.1
Mo:	St. Louis [a] [c]	2.41	1.8	3.8	5	26	80	1.7
Ohio:	Cleveland	1.34	.9	2.2	5	11	50	.9
Pa:	Pittsburgh [a]	2.20	1.2	3.1	5	21	45	1.4
S.C:	Charleston [a]	1.58	1.0	2.2	5	22	55	2.1
S. Dak:	Sioux Falls [c]	1.69	1.3	2.5	5	20	70	1.1
Tex:	Austin	1.69	.9	2.1	5	12	25	2.1
Vt:	Burlington [a]	1.27	.8	2.0	5	15	55	.8
Wash:	Seattle [b]							
Institutional average		1.79	1.2	2.6	5	19	55	1.6

[a] The averages for these stations were restricted to include data for only those months for which food samples were collected from children 9–12 years of age.
[b] Diet samples were collected throughout the year from children other than 9–12 years of age.
[c] At these institutions no total diet samples was collected during one or more months of the year.

age. During this period calcium intakes varied from 0.8 to 1.8 g/day, with a mean of 1.2 g/day. Potassium annual average intake ranged from 2.0 to 3.8 g/day with a mean of 2.6 g/day.

Annual average daily intakes of strontium–89 were less than 10 pCi/day at each station. During 1966 annual average strontium–90 intakes ranged from 10 to 32 pCi/day with a mean of 19 pCi/day. Half of the stations' annual averages fall in FRC Range I and half fall in Range II (*6*), indicating that quantitative surveillance and routine control are the recommended course of action.

Cesium–137 annual average intakes ranged from 25 to 140 pCi/day with a mean of 55 pCi/day. At the same time radium–226 intakes averaged 1.6 pCi/day.

Detectable low levels of iodine–131 were seen at the Sioux Falls station in June, Louisville in October and Phoenix, Palmer, Tampa, and New Orleans in December. Also some detectable barium–140 activity was seen in Palmer, Los Angeles, and Austin.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1966	April 1967
October–December 1966	July 1967

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2. Estimated daily intake of radionuclides in California diets, September–December 1966, January–February 1967

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*7*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest (figure 2).

Hospitals were chosen as the source of diet samples under the hypothesis that their diets are as "reasonably representative" as any other. General hospitals exist in each of the 20 selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory of the State Department of Public Health. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the laboratory, each sample is homogenized and analyzed for gamma-ray emitters, then dried and ashed prior to analysis for strontium–89, strontium–90, radium–226, and stable calcium, strontium, and sodium.

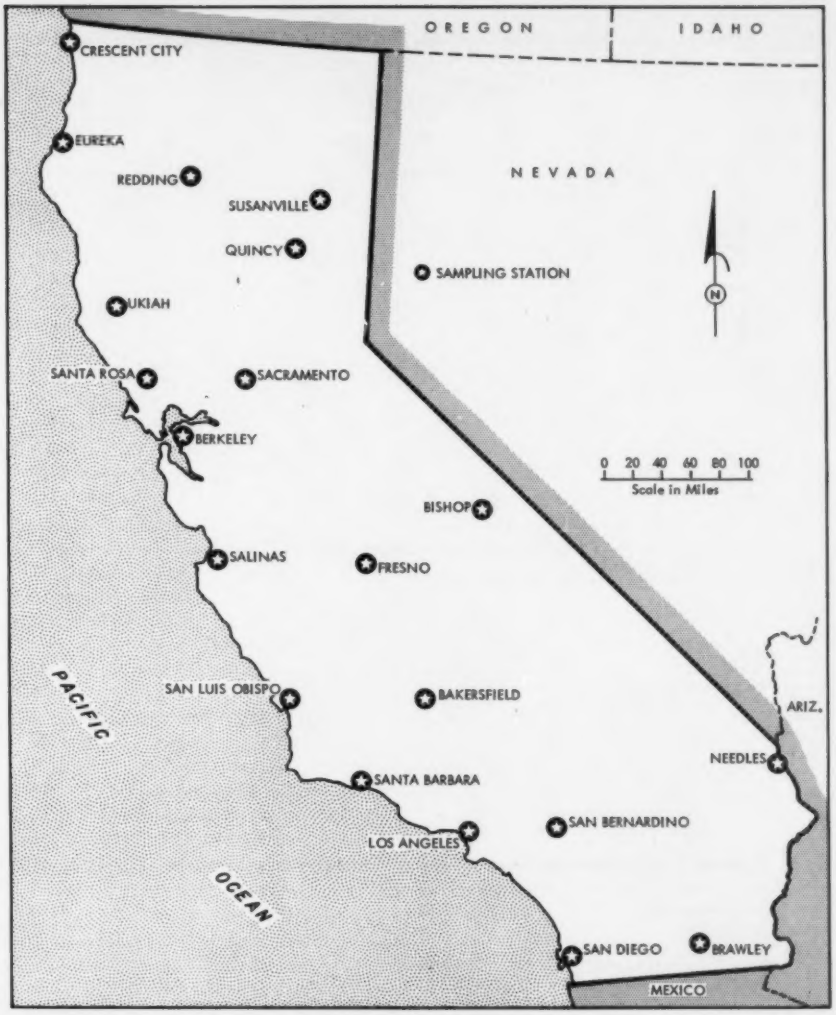

Figure 2. California diet sampling locations

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in table 5 (September–October 1966), table 6 (November–December 1966), and table 7 (January–February 1967).

It should be noted that levels of radioactivity were observed to be far below those levels for which consideration should be given to protective health action. A summary of strontium–90 and cesium–137 intake trends in California diets from January 1964 through February 1967 is given in figures 3 and 4.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–April 1966	January 1967
May–August 1966	May 1967

Table 5. Estimated daily intake of radionuclides in California diets, September–October 1966 [a]

City	Consumption (kg/capita•day) [b]	Intake (pCi/capita•day)						Intake (g/capita•day)			
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K [c]	Na	Ca	Stable strontium
Bakersfield	2.1	5	1.3	16	0	0	0	2.6	3.3	0.9	0.002
Berkeley	2.3	10	1.2	36	0	0	0	2.5	3.4	.6	.001
Bishop	2.3	10	1.2	38	3	6	11	3.0	5.0	.9	.003
Brawley	1.7	6	1.0	13	4	0	0	2.0	2.7	.7	.005
Crescent City	1.9	12	0.9	28	0	0	0	2.1	4.1	.6	.002
Eureka	2.3	16	1.2	35	0	0	0	2.7	4.0	.9	.005
Fresno	1.9	6	.5	22	0	0	0	2.0	3.6	.6	.002
Los Angeles	2.4	11	1.4	35	0	0	0	3.0	4.1	1.6	.005
Needles	2.0	7	.8	22	0	0	0	2.8	2.9	.8	.003
Quincy	1.0	6	.4	16	0	0	0	1.3	1.4	.4	.001
Redding	1.9	7	1.2	21	0	0	0	1.3	2.9	.7	.001
Sacramento	2.7	10	1.1	27	0	0	0	3.0	5.5	1.2	.003
Salinas	2.3	8	.9	38	0	0	0	2.8	5.8	.7	.002
San Bernardino	1.8	4	.7	20	0	0	0	2.0	2.4	.6	.002
San Diego	2.3	13	1.3	28	0	0	0	2.9	2.4	.9	.003
San Luis Obispo	1.3	7	.7	11	0	0	0	1.8	3.4	.7	.002
Santa Barbara	2.3	7	.7	25	0	0	0	3.0	3.7	1.1	.003
Santa Rosa	2.3	6	.9	25	0	0	0	2.5	3.3	.9	.003
Susanville	1.9	7	.9	31	0	0	0	2.2	3.2	.7	.003
Ukiah	2.7	6	.5	21	0	0	0	2.7	3.6	1.1	.002

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 was not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.

Table 6. Estimated daily intake of radionuclides in California diets, November–December 1966 [a]

City	Consumption (kg/capita•day) [b]	Intake (pCi/capita•day)					Intake (g/capita•day)			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	K [c]	Na	Ca	Stable strontium
Bakersfield	2.3	1	6	0.6	10	0	3.0	3.8	1.5	0.003
Berkeley	2.0	1	6	1.2	17	0	2.1	3.6	0.6	.003
Bishop	1.9	0	8	1.0	23	0	2.7	3.3	1.7	.004
Brawley	1.8	1	6	.8	18	0	2.5	3.7	.7	.004
Crescent City	2.2	9	11	.5	23	0	3.0	5.5	.7	.003
Eureka	2.2	4	12	.3	31	0	2.4	3.4	.8	.002
Fresno	2.4	1	5	1.6	23	0	2.6	3.8	.5	.002
Los Angeles	1.8	2	5	.3	27	[d] 2	1.4	2.7	1.0	.003
Needles	1.9	0	6	.6	18	0	2.0	3.4	.7	.005
Quincy	1.8	2	6	.5	20	0	2.7	4.0	.6	.005
Redding	NS									
Sacramento	2.6	0	6	2.0	15	4	3.9	4.5	1.4	.003
Salinas	NS									
San Bernardino	1.9	1	4	.9	23	0	2.4	3.4	.9	.003
San Diego	1.9	1	5	.5	15	0	2.5	2.0	.7	.002
San Luis Obispo	1.5	1	6	3.1	18	0	2.0	3.2	.7	.002
Santa Barbara	2.1	1	11	.7	19	4	2.5	3.6	1.1	.004
Santa Rosa	1.7	2	4	.5	18	0	1.8	2.9	.9	.002
Susanville	1.9	1	6	ND	18	0	2.7	4.5	.9	.002
Ukiah	2.6	1	10	1.0	21	[d] 3	3.0	5.3	1.3	.006

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate but is not statistically significant.
NS, no sample collected or analyzed.
ND, not detectable.

Table 7. Estimated daily intake of radionuclides in California diets, January–February 1967 [a]

City	Consumption (kg/capita•day)[b]	Intake (pCi/capita•day)							Intake (g/capita•day)			
		^{89}Sr	^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K[c]	Na	Ca	Stable strontium
Bakersfield	2.1	0	5	0.5	9	1	0	0	2.5	3.9	1.1	0.003
Berkeley	2.1	1	6	1.3	34	0	0	0	2.6	4.3	0.8	.004
Bishop	2.3	0	10	1.4	15	0	0	0	2.8	4.8	1.6	.003
Brawley	1.8	2	6	.7	10	0	0	0	1.9	2.2	1.0	.002
Crescent City	2.2	7	12	.7	26	0	0	0	2.3	4.2	.8	.005
Eureka	2.2	[d] 1	8	1.0	23	0	0	0	2.3	3.8	1.1	.003
Fresno	2.4	1	5	1.8	29	0	0	0	2.5	3.6	.7	.005
Los Angeles	2.1	2	7	.8	23	6	0	7	2.6	4.1	.9	.004
Needles	2.3	1	8	.3	17	0	0	2	2.5	3.9	1.0	.005
Quincy	2.2	0	10	1.2	40	0	0	0	2.2	3.2	1.1	.003
Redding	2.2	0	8	.7	31	0	0	0	2.4	3.2	.9	.003
Sacramento	2.5	[d] 3	7	1.2	21	4	0	0	2.4	4.6	1.3	.004
Salinas	2.3	[d] 1	4	1.1	29	0	0	0	2.6	5.0	.7	.003
San Bernardino	2.3	[d] 1	9	1.0	7	0	0	0	3.2	4.1	1.2	.003
San Diego	2.0	[d] 1	7	1.0	27	0	0	0	2.4	3.0	.8	.004
San Luis Obispo	1.5	2	6	1.0	18	0	0	0	1.9	3.7	1.1	.003
Santa Barbara	2.2	1	8	.9	17	1	0	0	2.3	3.6	1.1	.003
Santa Rosa	2.0	[d] 2	7	1.3	14	1	0	0	2.2	3.6	1.0	.005
Susanville	1.9	[d] 2	4	.5	22	0	0	0	2.0	3.7	.8	.002
Ukiah	2.4	0	5	1.6	28	0	0	0	2.2	3.6	.9	.004

[a] Based on analyses of Hospital Standard Diets located in listed cities.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant.

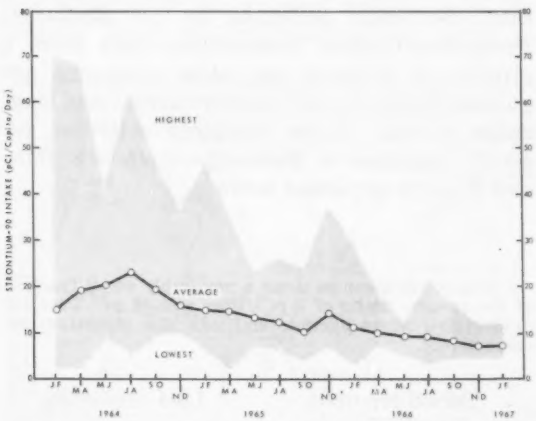

Figure 3. Averages and ranges of daily strontium-90 intake in California diets, 1964–February 1967

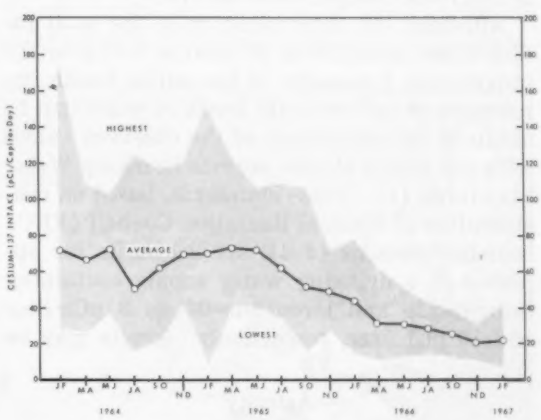

Figure 4. Averages and ranges of daily cesium-137 intake in California diets, 1964–February 1967

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence of strontium–90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analyses indicate that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium–90, respectively.

Activity	Period reported	Last presented
California Water Sampling Program	January–June 1966	June 1967
Coast Guard Water Sampling Program	1965	November 1966
Minnesota Surface Water Sampling Program	January–June 1966	January 1967
New York Surface Water Sampling Program	June–December 1965	June 1966
Radiostrontium in Tap Water, HASL	March–November 1966	June 1967
Washington Surface Water Sampling Program	July 1965–June 1966	August 1967

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Gross Radioactivity in Surface Waters of the United States, April 1967

Division of Pollution Surveillance
Federal Water Pollution Control Administration
Department of Interior

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as part of the Federal Water Pollution Control Administration's Water Pollution Surveillance System. Table 1 presents the current preliminary results of the alpha- and beta-particle analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium–90 results are reported semiannually. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 indicates the average total beta radioactivity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the August 1967 issue of *Radiological Health Data and Reports.*

Complete data and exact sampling locations for 1958 through 1963 are published in annual compilations (*1–6*). Data for subsequent years are available on request.

Special note is taken when the alpha radioactivity is 15 pCi/liter or greater or when the the beta radioactivity is 150 pCi/liter or greater. These Arbitrary levels provide a basis for the selection of data and for additional comment. They reflect no public health significance as the Public Health Service drinking water standards have already provided the basis for this assess-

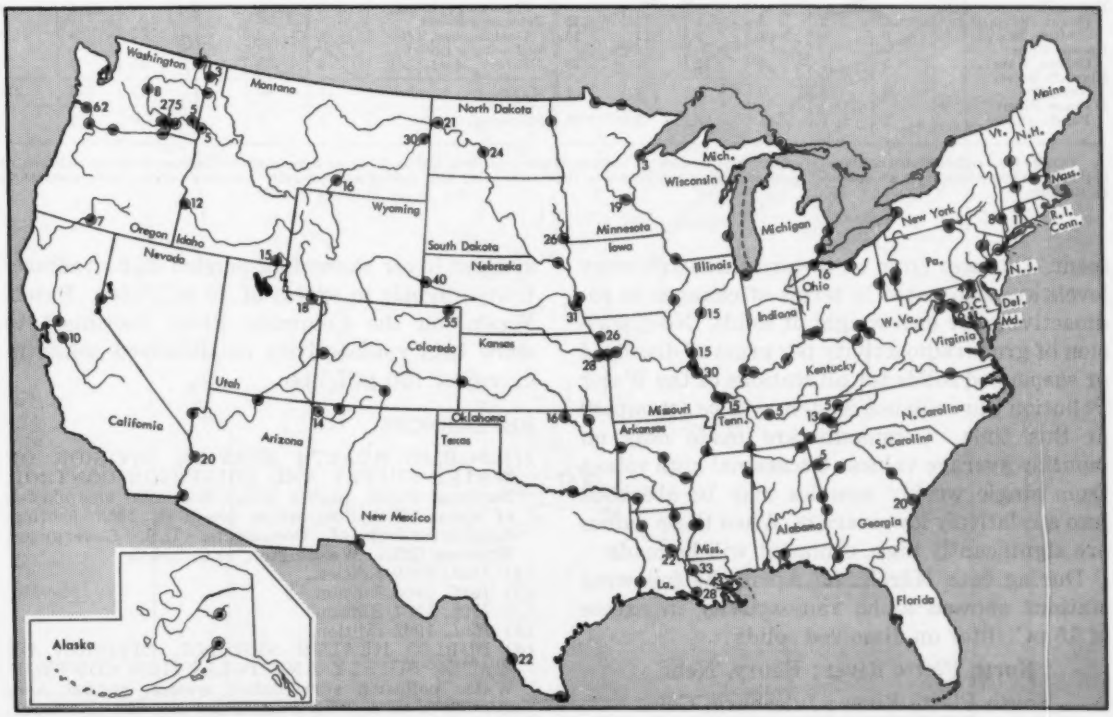

Figure 1. Sampling locations and associated total beta radioactivity (pCi/liter) in surface waters, April 1967

Table 1. Radioactivity in raw surface waters, April 1967

Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)			Station	Average alpha radioactivity (pCi/liter)			Average beta radioactivity (pCi/liter)		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total		Suspended	Dissolved	Total	Suspended	Dissolved	Total
Arkansas River:							Mississippi River:						
Ponca City, Okla	0	2	2	4	12	16	St. Paul, Minn	0	2	2	2	17	19
Atchafalaya River:							E. St. Louis, Ill	6	1	7	22	8	30
Morgan City, La	7	1	8	21	7	28	New Roads, La	2	2	4	11	22	33
Bear River:							New Orleans, La	16	0	16	35	8	43
Preston, Idaho	0	1	1	1	14	15	Missouri River:						
Big Horn River:							Williston, N. Dak	1	2	3	7	14	21
Hardin, Mont	0	3	3	4	12	16	Bismarck, N. Dak	3	2	5	11	13	24
Big Sioux River:							St. Joseph, Mo	1	4	5	9	17	26
Sioux Falls, S. Dak	1	4	5	6	20	26	North Platte River:						
Clearwater River:							Henry, Nebr	< 1	30	30	4	36	40
Lewiston, Idaho	< 1	0	< 1	2	3	5	Ohio River:						
Clinch River:							Cairo, Ill	1	0	1	7	8	15
Clinton, Tenn	0	0	0	1	4	5	Pend Oreille River:						
Kingston, Tenn [a]	0	< 1	< 1	1	12	13	Albeni Falls Dam, Idaho	0	1	1	< 1	3	3
Colorado River:							Platte River:						
Parker Dam, Calif-Ariz	0	6	6	0	20	20	Plattsmouth, Nebr	3	7	10	10	21	31
Columbia River:							Potomac River:						
Wenatchee, Wash	0	2	2	1	7	8	Washington, D.C	0	1	1	1	5	6
Pasco, Wash [a]	0	1	1	42	233	275	Red River, South:						
Clatskanie, Ore	0	1	1	14	48	62	Alexandria, La	3	1	4	13	9	22
Connecticut River:							Rio Grande:						
Enfield Dam, Conn	< 1	2	2	2	9	11	Laredo, Tex	3	3	6	10	12	22
Coosa River:							San Joaquin River:						
Rome, Ga	< 1	< 1	< 1	1	4	5	Vernalis, Calif	1	2	3	2	8	10
Cumberland River:							San Juan River:						
Cheatham Lock, Tenn	0	0	0	1	4	5	Shiprock, N. Mex	0	2	2	2	12	14
Delaware River:							Savannah River:						
Philadelphia, Pa	0	0	0	2	5	7	Port Wentworth, Ga [a]	0	0	0	2	18	20
Great Lakes:							Snake River:						
Duluth, Minn	0	0	0	0	3	3	Payette, Idaho	< 1	5	5	3	9	12
Green River:							Wawawai, Wash	0	1	1	1	4	5
Dutch John, Utah	0	5	5	1	17	18	South Platte River:						
Hudson River:							Julesburg, Colo	0	34	34	4	51	55
Poughkeepsie, N.Y	0	0	0	2	6	8	Susquehanna River:						
Illinois River:							Conowingo, Md	0	0	0	2	2	4
Peoria, Ill	1	2	3	4	11	15	Tennessee River:						
Grafton, Ill	0	1	1	2	13	15	Chattanooga, Tenn	0	1	1	0	4	4
Kansas River:							Yellowstone River:						
DeSota, Kans	3	1	4	17	11	28	Sidney, Mont	4	5	9	16	14	30
Klamath River:							Maximum	16	34	34	42	233	275
Keno, Ore	0	0	0	1	6	7	Minimum	0	0	0	0	2	3
Maumee River:													
Toledo, Ohio	2	2	4	7	9	16							

[a] Gross beta radioactivity at this station may not be directly comparable to gross beta radioactivity at other stations because of the possible contribution of radionuclides from an upstream nuclear facility in addition to the contribution from fallout and naturally occurring radionuclides, common to all stations.

ment. Changes from or toward these arbitrary levels are also noted in terms of changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

During both March and April, the following stations showed alpha radioactivity in excess of 15 pCi/liter on dissolved solids:

North Platte River; Henry, Nebr.

South Platte River; Julesburg, Colo.

During April, New Orleans, La., on the Mississippi River showed suspended alpha radioactivity slightly in excess of 15 pCi/liter. Pasco, Wash., on the Columbia River continued to show beta radioactivity on dissolved solids in excess of 150 pCi/liter.

REFERENCES

(1) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. National water quality network annual compilation of data, PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

(2) *Ibid.*, 1959 Edition.

(3) *Ibid.*, 1960 Edition.

(4) *Ibid.*, 1961 Edition.

(5) *Ibid.*, 1962 Edition.

(6) PUBLIC HEALTH SERVICE, DIVISION OF WATER SUPPLY AND POLLUTION CONTROL. Water pollution surveillance system, annual compilation of data, PHS Publication No. 663 (Revised), 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Radioactivity in Minnesota Municipal Water Supplies, July–December 1966[1]

Division of Environmental Sanitation, Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 250-ml sample of water is transferred to a 2-inch planchet and

[1] Data and information from "Survey of Environmental Radioactivity, July–December 1966," Publication No. COO–651–41. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440.

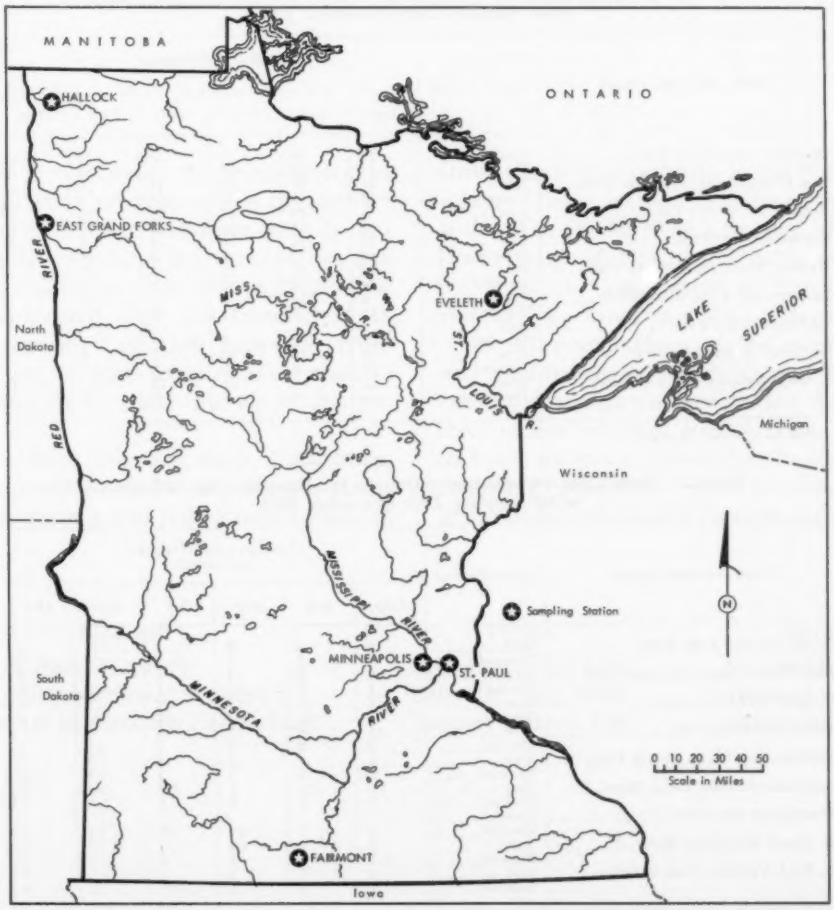

Figure 1. Minnesota surface water sampling locations

evaporated at 75° C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for alpha or beta radioactivity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from July–December 1966. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 4 to 26 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Table 1. Total beta-particle concentrations in Minnesota raw and treated water supplies, July–December 1966

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	21	18	19	16	16	25
	Treated	26	22	21	19	22	19
East Grand Forks, Red Lake River	Raw	24	21	20	16	18	16
	Treated	12	13	11	8	9	9
Eveleth, St. Mary's Lake	Raw	13	13	13	11	12	12
	Treated	14	14	16	12	12	12
Fairmount, Budd Lake	Raw	15	14	15	14	11	17
	Treated	8	6	9	8	11	6
Halleck, Two Rivers, South Fork	Raw	18	17	21	17	18	24
	Treated	12	10	7	7	7	7
International Falls, Rainy River	Raw	9	11	9	7	NS	9
	Treated	14	9	11	9	NS	8
Minneapolis tap water	Raw						
	Treated	8	7	6	7	4	4
St. Cloud, Mississippi River	Raw	15	12	10	7	9	9
	Treated	5	5	10	5	5	4
St. Paul, Vadnais Chain of Lakes	Raw	12	14	14	12	11	12
	Treated	9	7	8	8	8	5

NS, no samples collected.

Table 2. Total alpha-particle concentrations in Minnesota raw and treated water supplies, July–December 1966

Town and water source	Type of water	Average concentrations (pCi/liter)					
		July	Aug	Sept	Oct	Nov	Dec
Crookston, Red Lake River	Raw	4	1	3	1	<2	<2
	Treated	3	3	2	<1	<2	<3
East Grand Forks, Red Lake River	Raw	4	3	1	1	1	<2
	Treated	1	3	<1	<1	<2	<2
Eveleth, St. Mary's Lake	Raw	<1	<1	<1	<1	<1	<1
	Treated	1	<1	1	<1	<1	<2
Fairmount, Budd Lake	Raw	11	6	7	8	6	3
	Treated	2	2	1	2	<1	<1
Halleck, Two Rivers, South Fork	Raw	2	1	2	2	<3	<3
	Treated	2	1	1	1	<2	<3
International Falls, Rainy River	Raw	1	<1	1	1	NS	<1
	Treated	1	1	1	2	NS	<1
Minneapolis tap water	Raw						
	Treated	1	1	<1	<1	<1	<1
St. Cloud, Mississippi River	Raw	1	1	<1	1	<2	<2
	Treated	<1	1	<1	1	<1	<2
St. Paul, Vadnais Chain of Lakes	Raw	1	1	2	1	<1	<2
	Treated	1	1	<1	<1	<1	<2

NS, no sample collected.

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, the surveillance has been confined chiefly to gross beta-particle analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from the programs of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above programs was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
HASL Fallout Network	July–December 1966	September 1967
HASL 80th Meridian Network	Calendar Year 1965	January 1967
Plutonium in Airborne Particulates	January–March 1967	September 1967

1. Radiation Surveillance Network June 1967

National Center for Radiological Health and *National Center for Urban and Industrial Health, PHS*

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples at 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Md., for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta radioactivity made by the station operators. These estimates are made after the decay of radon and thoron daughter products and prior to submission of the samples for laboratory analysis. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*1*). A detailed description of the sampling and analytical procedures was presented in the November 1966 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air and deposition by precipitation during June 1967. Time profiles of gross beta radioactivity in air for eight RSN stations are shown in figure 2.

Air and precipitation samples were generally near or below detectable levels. The only elevation in air radioactivity occurred at Agana, Guam, on June 21 and 22, when the levels found were 0.80 pCi/m^3 and 0.58 pCi/m^3, respectively. Fresh fission products were identified by

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, June 1967

Station location		Number of samples		Air surveillance, gross beta radioactivity (pCi/m³)			Last profile in *RHD&R*	Precipitation	
		Air	Pptn	Maximum	Minimum	Average [a]		Total depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	30	7	0.06	0.01	0.03	Nov 66	136	<27
Alaska:	Adak	29	----------	.04	.00	.01	June 67	[b]	
	Anchorage	24	10	.03	.00	.01	Dec 66	37	< 8
	Attu Island	26	----------	.02	.00	.01	July 67	[b]	
	Fairbanks	[c]	----------	----------	----------	----------	Jan 67	[b]	
	Juneau	24	8	.05	.00	.02	Apr 67	126	<25
	Kodiak	5	----------	.02	.00	.01	May 67	[b]	
	Nome	[c]	----------	----------	----------	----------	Sept 67	[b]	
	Pt. Barrow	30	----------	.02	.00	.00	Aug 67	[b]	
	St. Paul Island	[c]	----------	----------	----------	----------	Oct 67	[b]	
Ariz:	Phoenix	30	----------	.10	.02	.05	Apr 67	[b]	
Ark:	Little Rock	29	6	.07	.01	.03	Dec 66	86	<17
Calif:	Berkeley	24	3	.06	.00	.02	May 67	33	< 7
	Los Angeles	24	----------	.04	.01	.03	Sept 67	[b]	
C. Z:	Ancon	20	----------	.03	.00	.01	May 67	[b]	
Colo:	Denver	29	12	.08	.01	.04	May 67	113	<23
Conn:	Hartford	29	7	.09	.01	.04	Apr 67	62	<13
Del:	Dover	24	----------	.06	.01	.04	Nov 66	[b]	
D. C:	Washington	30	3	.06	.02	.04	Aug 67	41	< 8
Fla:	Jacksonville	30	16	.06	.00	.02	Dec 66	242	<48
	Miami	30	12	.04	.01	.02	Apr 67	168	<34
Ga:	Atlanta	30	9	.06	.01	.03	Oct 67	139	<28
Guam:	Agana	30	----------	.80	.00	.06	Nov 66	[b]	
Hawaii:	Honolulu	30	----------	.05	.00	.02	July 67	[b]	
Idaho:	Boise	28	5	.21	.01	.05	July 67	32	< 7
Ill:	Springfield	29	9	.08	.02	.04	Aug 67	70	<14
Ind:	Indianapolis	30	3	.08	.02	.05	Oct 67	16	< 3
Iowa:	Iowa City	30	8	.09	.01	.04	May 67	196	<39
Kans:	Topeka	29	2	.09	.00	.03	Dec 66	37	< 7
Ky:	Frankfort	29	8	.08	.01	.04	Aug 67	46	< 9
La:	New Orleans	30	9	.05	.01	.02	Aug 67	165	<33
Maine:	Augusta	30	9	.08	.00	.05	Sept 67	236	<47
	Presque Isle	17	3	.10	.00	.05	May 67	28	< 6
Md:	Baltimore	23	2	.08	.02	.05	Apr 67	15	< 3
	Rockville	19	2	.07	.02	.04	July 67	44	< 9
Mass:	Lawrence	28	8	.10	.00	.06	Nov 66	116	<23
	Winchester	17	8	.07	.00	.04	June 67	49	<10
Mich:	Lansing	29	12	.08	.02	.04	July 67	148	<30
Minn:	Minneapolis	23	14	.06	.00	.03	Nov 66	188	<40
Miss:	Jackson	30	4	.05	.01	.02	Sept 67	68	<14
Mo:	Jefferson City	30	11	.07	.01	.03	Oct 67	170	<34
Mont:	Helena	30	13	.11	.01	.05	June 67	56	<12
Nebr:	Lincoln	18	11	.12	.01	.04	Oct 67	365	<73
Nev:	Las Vegas	29	----------	.08	.01	.04	Jan 67	[b]	
N. H:	Concord	23	----------	.09	.01	.06	Aug 67	[b]	
N. J:	Trenton	29	3	.07	.01	.04	Sept 67	16	< 3
N. Mex:	Santa Fe	29	5	.06	.01	.03	June 67	27	< 6
N. Y:	Albany	24	4	.08	.01	.05	Oct 67	51	<10
	Buffalo	29	----------	.08	.02	.05	May 67	[b]	
	New York City	30	----------	.08	.01	.04	June 67	[b]	
N. C:	Gastonia	30	8	.08	.01	.04	May 67	121	<24
N. Dak:	Bismarck	30	8	.09	.01	.05	Aug 67	22	< 4
Ohio:	Cincinnati	17	----------	.07	.02	.04	Nov 66	[b]	
	Columbus	30	2	.12	.03	.07	Sept 67	33	< 7
	Painesville	29	8	.08	.02	.05	Apr 67	51	<10
Okla:	Oklahoma City	30	6	.05	.01	.02	July 67	64	<13
	Ponca City	24	10	.03	.00	.01	Apr 67	244	<49
Ore:	Portland	29	5	.07	.00	.03	Oct 67	22	< 4
Pa:	Harrisburg	30	----------	.10	.01	.04	Oct 67	[b]	
P. R:	San Juan	29	7	.08	.02	.04	Sept 67	131	<26
R. I:	Providence	30	8	.06	.00	.03	July 67	60	<12
S. C:	Columbia	25	6	.05	.01	.03	June 67	81	<16
S. Dak:	Pierre	29	6	.08	.02	.04	Apr 67	154	<31
Tenn:	Nashville	29	8	.06	.01	.03	July 67	100	<20
Tex:	Austin	30	----------	.07	.01	.03	Nov 66	[b]	
	El Paso	28	5	.06	.01	.03	Aug 67	16	< 3
Utah:	Salt Lake City	28	14	.09	.01	.05	Sept 67	62	<12
Vt:	Barre	27	8	.10	.01	.05	Dec 66	53	<11
Va:	Richmond	29	4	.07	.01	.04	Dec 66	50	<10
Wash:	Seattle	30	2	.06	.00	.02	Dec 66	25	< 5
	Spokane	30	2	.11	.01	.04	Nov 66	38	< 8
W. Va:	Charleston	30	6	.07	.01	.04	June 67	43	< 9
Wis:	Madison	29	12	.60	.01	.05	Dec 66	152	<31
Wyo:	Cheyenne	30	13	.15	.00	.04	Jan 67	72	<14
Network summary		1,931	394	0.80	0.00	0.03	----------	91	<18

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
[b] No precipitation sample collected.
[c] No report received.

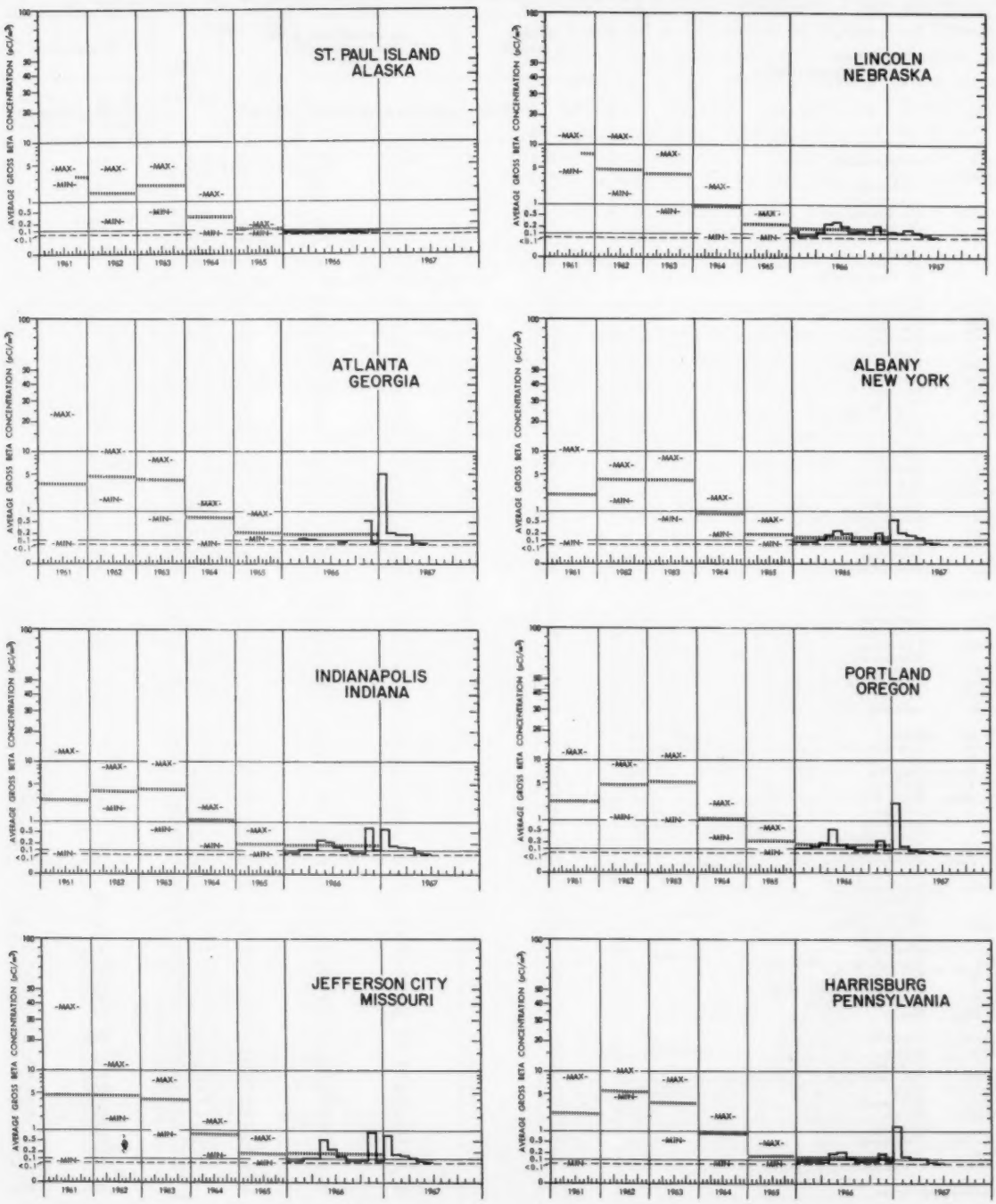

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Surveillance Network, 1961–June 1967

gamma-ray spectroscopy on the June 21 sample. The one precipitation sample more active than the minimum reporting level of 200 pCi/liter was collected at Minneapolis, Minn., on June 29 and contained 2.9 nCi/m² of gross beta radioactivity. Fission products were identified on this sample but decay data indicates that the radioactive material was more than 100 days old.

2. Canadian Air and Precipitation Monitoring Program, June 1967 [1]

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*2–6*).

A summary of the sampling procedures and methods of analysis was presented in the November 1966 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for June 1967 are presented in table 2.

[1] Prepared from information and data in the July 1967 monthly report "Data from Radiation Protection Program," Canadian Department of National Health and Welfare, Ottawa, Canada.

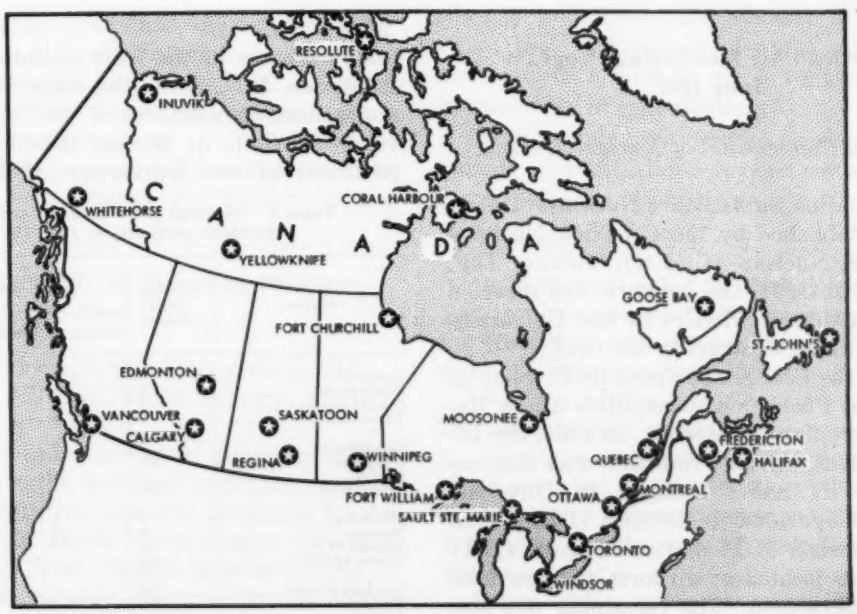

Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta radioactivity in surface air and precipitation, June 1967

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentrations pCi/liter)	Total deposition (nCi/m³)
Calgary	30	0.1	0.0	0.0	18	1.0
Coral Harbour	27	.0	.0	.0	22	.8
Edmonton	30	.1	.0	.0	10	.6
Ft. Churchill	30	.1	.0	.0	6	.7
Ft. William	30	.1	.0	.0	19	1.7
Fredericton	30	.1	.0	.0	6	.6
Goose Bay	30	.1	.0	.0	45	2.4
Halifax	30	.1	.0	.0	15	.7
Inuvik	30	.1	.0	.0	25	.8
Montreal	30	.1	.0	.0	11	1.4
Moosonee	30	.1	.0	.0	21	.6
Ottawa	30	.1	.0	.0	15	1.7
Quebec	30	.1	.0	.0	10	1.5
Regina	29	.1	.0	.0	44	1.3
Resolute	29	.0	.0	.0	NS	NS
St. John's, Nfld.	30	.1	.0	.0	20	.4
Saskatoon	30	.1	.0	.0	22	1.2
Saulte Ste. Marie	30	.1	.0	.0	18	1.4
Toronto	30	.1	.0	.0	9	1.2
Vancouver	30	.1	.0	.0	42	.5
Whitehorse	30	.1	.0	.0	90	.6
Windsor	30	.1	.0	.0	14	1.3
Winnipeg	30	.1	.0	.0	27	1.4
Yellowknife	28	.1	.0	.0	38	.8
Network summary	30	0.1	0.0	0.0	24	1.1

NS, no sample collected.

3. Mexican Air Monitoring Program June 1967

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the

Table 4. Mexican gross beta radioactivity of airborne particulates, June 1967

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	3	0.1	0.1	0.1
Chihuahua	5	.1	.1	.1
Ciudad Juárez	7	.1	< .1	<.1
Ensenada	7	.1	< .1	<.1
Guadalajara	4	.1	.1	.1
Guaymas	NS			
La Paz	6	.1	.1	.1
Matamoros	NS			
Mazatlán	4	.1	.1	.1
Mérida	9	.3	< .1	.1
México, D.F.	3	.1	.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	4	.1	< .1	<.1
Veracruz	1	.1	.1	.1

NS, no sample collected, station temporarily shutdown.

Figure 4. Mexican air sampling locations

Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high-volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of eight samples per month were needed to get a reliable average radioactivity at each station (*7*).

The maximum, minimum, and average beta-particle concentrations in surface air during June 1967 are presented in table 4.

4. Pan American Air Sampling Program June 1967

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the National Center for Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling sites are shown in figure 5.

The June 1967 air monitoring results from the participating countries are given in table 5. Increases in airborne gross beta radioactivity occurred in all reporting stations south of the equator. Those samples more active than 1.0 pCi/m^3 at the time of collection are presented in table 6.

Fresh fission products were identified by gamma-ray spectroscopy on 14 samples including those containing radioactivity greater than

Figure 5. Pan American Air Sampling Program stations

Table 5. PAHO gross beta radioactivity in surface air June 1967

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average [a]
Argentina, Buenos Aires	19	0.62	0.01	0.09
Bolivia, La Paz	19	17.50	.01	1.91
Chile, Santiago	30	.48	.01	.09
Colombia, Bogota	19	.01	.00	.00
Ecuador, Guayaquil	1	.18	.18	.18
Jamaica, Kingston	17	.05	.01	.03
Peru, Lima	25	1.67	.00	.25
Venezuela, Caracas	18	.03	.00	.01
West Indies, Trinidad	20	.04	.00	.02
Pan American summary	168	17.50	0.00	0.28

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

1.0 pCi/m³. Other samples which had probably been more radioactive than 1.0 pCi/m³ at collection, were not received until 3 to 4 weeks after collection and while still containing more radioactivity than normal levels, had decayed sufficiently so that decay calculations and gamma-ray spectroscopy were not feasible.

The data show that one or two intrusions of fresh fission products occurred at those stations south of the equator and there is some indication from the data that the debris was concentrated at higher altitudes.

Table 6. Samples from PAHO member countries which contained radioactivity greater than 1 pCi/m³

Location	Date	Gross beta radioactivity at collection (pCi/m³)
Peru: Lima	June 20	1.04
	23	1.67
Bolivia: La Paz	June 14	1.04
	15	17.50
	16	11.05
	17–20	2.90
	22–23	3.10
	24–26	1.28

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission receives from its contractors semi-annual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, Knolls Atomic Power Laboratory, and the S1C Prototype Reactor Facility.

[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Bettis Atomic Power Laboratory July–December 1966 [2]

Westinghouse Electric Corporation
Pittsburgh, Pennsylvania

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

[2] Summarized from "Environmental Radioactivity at the Bettis Atomic Power Laboratory for the Second 6 Months of 1966" (PNR–SMD–140).

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium–90 radioactivity.

The average concentration of gross beta radioactivity in the main laboratory liquid effluent during this period was 5.5×10^2 pCi/liter. This was higher than the average concentration of 1.5×10^2 pCi/liter observed for the first 6 months of 1966. The maximum and minimum gross beta radioactivity detected in the weekly samples amounted to concentrations of 1,800 pCi/liter and 35 pCi/liter, respectively.

The average concentration of gross alpha particle activity in the main laboratory effluent was 5.6 pCi/liter; a reduction from the 7.4 pCi/liter average for the previous 6-month period.

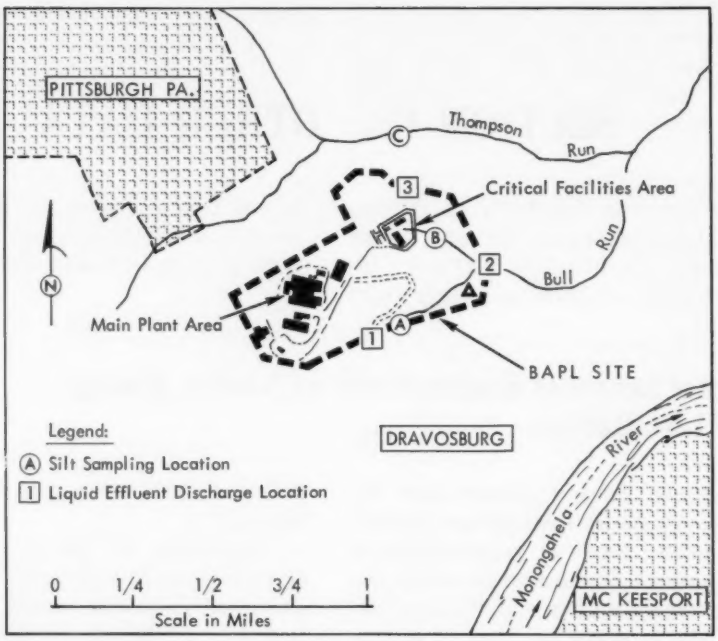

Figure 1. Bettis Atomic Power Laboratory sampling stations

The maximum gross alpha particle radioactivity detected in weekly samples during this period was 19 pCi/liter while the minimum concentration was 1.0 pCi/liter.

The average concentration of strontium–90 in liquid waste was 42 pCi/liter as compared with 3.9 pCi/liter for the first 6 months of 1966.

Average radioactivity in liquid waste effluent from the critical facility operations during the second half of 1966 were: alpha radioactivity—1.3×10^2 pCi/liter, beta-gamma radioactivity—5.2×10^2 pCi/liter. Comparable values for the first 6 months in 1966 were <68 pCi/liter for alpha radioactivity and 1.3×10^3 pCi/liter for beta-gamma radioactivity.

Background monitoring stations

Beta-gamma background radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the controlled confines of the Bettis Atomic Power Laboratory site.

The average beta-gamma background radiation level during the fourth quarter of 1966 was 0.051 mR/hr for the main laboratory area and 0.010 mR/hr for the critical facility area. The respective average exposure values for the previous period from January 1 through June 30, 1966, were 0.067 mR/hr and 0.028 mR/hr. Table 1 summarizes results obtained during the second half of 1966 from the background monitoring stations.

Table 1. Beta-gamma background radiation monitoring Bettis, October–December 1966 [a]

Location	Exposure levels (mR/hr)	
Main laboratory area (20 locations)	Maximum	0.358
	Minimum	.018
	Average	*.051
Critical facility area (14 locations)	Maximum	.026
	Minimum	< .004
	Average	*.010
All locations	Average	.030

[a] Third quarter results were considered invalid and questionable, therefore, only the fourth quarter results were used to determine the average levels for the second half of 1966.

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radioactivity concentrations of stream silt samples were 0.83 pCi/g and 14 pCi/g, respectively, for the second half of 1966. The average alpha-particle concentration was higher than the concentration of 0.65 pCi/g for the first 6 months of 1966. The average beta-gamma concentration was lower than the concentration of 22 pCi/g for the first 6 months of 1966.

Semiannual analyses for strontium–89 and strontium–90 were obtained for composites of quarterly silt samples. Table 3 presents the results of these analyses for samples collected during the first 6 months of 1966.

Table 2. Radioactivity in stream silt, Bettis July–December 1966

Period 1966	Location *	Radioactivity concentration (pCi/g)	
		Alpha	Beta-gamma
July–September	A	0.91	5.2
	B	1.3	1.6
	C	1.2	1.1
	Average	1.4	2.6
October–December	A	.40	58
	B	.20	11
	C	.15	6.8
	Average	.25	25
Second half	Average	.82	14

* Refer to figure 1 for locations.

Table 3. Strontium-89 and strontium-90 in stream silt (6-month composite) Bettis, January–June 1966

Location *	Concentration (pCi/g of silt)	
	Strontium-89	Strontium-90
A	0.090	0.22
B	.031	.05
C	.027	.072

* See figure 1 for locations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	October 1966
January–June 1966	April 1967

2. Knolls Atomic Power Laboratory July–December 1966 [3]

General Electric Company
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the AEC in the development of atomic power for naval propulsion. This includes design, construction, and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site (figure 2). The Knolls site occupies approximately 170 acres on which are located administrative buildings; chemistry, physics, metallurgical, engineering, and radio-

Figure 2. Environmental monitoring locations, KAPL

[3] Summarized from "Knolls Atomic Power Laboratory, Semiannual Environmental Monitoring Report, July–December 1966."

active materials laboratories; critical assembly buildings; machine shops, decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building, and waste treatment facilities. Regular environmental monitoring activities are conducted to assure that laboratory releases of radioactivity to the environment are in compliance with AEC standards.

Air monitoring

Environmental airborne radioactivity is measured at two locations on the Knolls site, four locations at the West Milton site, and at the General Electric Company Research Laboratory approximately 1-mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis. Each environmental monitoring stations is equipped with film dosimeters to detect integrated gamma radioactivity levels. The average airborne beta and gamma radioactivity at each of the three areas is summarized in table 4 for the 6-month period.

Table 4. Airborne radioactivity, KAPL, July–December 1966

Sampling period 1966	Average beta and gamma radioactivity [a] (pCi/m³)		
	Knolls site	West Milton	Offsite
July	0.14±0.01	0.18±0.03	0.12±0.01
August	.07± .01	.10± .02	.07± .01
September	.03± .01	.04± .02	.04± .01
October	.02± .01	.04± .02	.02± .01
November	.11± .01	.18± .02	.12± .01
December	.04± .01	.06± .02	.04± .1
July–December	0.07	0.10	0.07

[a] Samples are counted a minimum of 48 hours after collection to allow short-lived natural radionuclides to decay to nondetectable levels.

In addition to the environmental airborne radioactivity monitoring, surveys are made semiannually of the radiation levels at the perimeter of KAPL at both the West Milton and Knolls sites. A recent perimeter survey at the site showed normal background radiation levels for the geographic location. The results of this perimeter survey, extrapolated to an annual exposure, indicate average perimeter radiation levels of less than one-tenth roentgen per year.

Water monitoring

All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste-processing building. The release of liquid waste to the Mohawk River is regulated through the monitoring of the concentration of fission products in the collection tanks and the control of the discharge rate of the effluent.

A continuous proportional sample of the Knolls site combined-sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of the weekly composite samples show that strontium–90 is the principal radionuclide to be considered in control. The average weekly strontium–90 concentration during the period was 38 pCi/liter. The AEC radiation protection standard for this radionuclide is 300 pCi/liter. The quantity of radioactive material in the combined-sewer effluent discharged from the Knolls site has been summarized in table 5.

Table 5. Beta and gamma radioactivity in the Knolls site liquid waste effluent, July–December 1966

Sampling period 1966	Total radioactivity (mCi)	Average concentration (pCi/liter)
July	4.5	34
August	8.6	51
September	9.8	52
October	3.3	21
November	62.9	3.7×10^3
December	25.5	1.8×10^3
July–December	114.6	1.18×10^3

Mohawk River water is sample continuously at the point of discharge from the Knolls site; at the General Electric Company powerhouse 8-miles upstream from the site; at the Vischer Ferry powerhouse approximately 2-miles downstream; and at the City of Cohoes pumping station about 13 miles downstream. Results of this sampling along with those for precipitation are given in table 6.

The Knolls site effluent is sampled continuously for alpha radioactivity. During the second half of 1966 the semiannual discharge rate of alpha-particle emitters was less than 1 percent of the AEC environmental limit for an alpha-particle emitting radionuclide (5×10^3

Table 6. Radioactivity in Mohawk River water and precipitation near the Knolls site, July–December 1966

Sampling period 1966	Beta and gamma radioactivity (pCi/liter)			
	G.E. Powerhouse (upstream)	Vischer Ferry (downstream)	Cohoes raw water (downstream)	Precipitation
July	13±4	14±4	8±4	0.5 $\times 10^3$
August	6±4	10±4	7±4	0.2 $\times 10^3$
September		7±4	9±4	0.08$\times 10^3$
October		6±4	7±4	0.10$\times 10^3$
November		7±4	9±4	* 3.50$\times 10^3$
December		5±4	4±4	0.20$\times 10^3$
July–December	9±4	8±4	7±4	0.76$\times 10^3$

* Increase due to weapons testing in Asia.

pCi/liter for plutonium–239). The radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release into Glowegee Creek. Samples of the Creek water are taken once a week at two locations, one is about 150 feet above the point where the S3G effluent enters the creek and the other is about 2,640 feet below the S3G discharge or 1,500 feet below the DIG discharge. Table 7 presents a summary of radioactive wastes discharged to Glowegee Creek in terms of total radioactivity and concentration in liquid wastes.

Table 7. Beta and gamma radioactivity in West Milton liquid-waste effluents, KAPL, July–December 1966

Sampling period 1966	Total radioactivity (mCi)		Average concentration (pCi/liter)	
	D1G effluent	S3G effluent	D1G effluent	S3G effluent
July	0.95	0.24	100	490
August	.69	.26	19	120
September	.68	.13	16	100
October	.54	.19	13	110
November	1.23	.24	75	150
December	.56	.14	100	120
July–December	4.65	1.20	26	120

Radiochemical analyses of these wastes indicated that strontium–89 and strontium–90 concentrations were less than 1 percent of the respective AEC standards during the first 3 months of this reporting period. The average results for unidentified radionuclides in the DGI and S3G effluents (26 and 120 pCi/liter) represent less than 1 percent and less than 4 percent of the applicable AEC standard of 3 x 10^3 pCi/liter.[4]

Table 8 presents the average concentrations of beta and gamma radioactivity detected in Glowegee Creek water upstream and downstream from the S3G and D1G liquid waste outfalls and in precipitation collected during this period.

[4] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains essentially the standards published in Chapter 0534 of the AEC Manual.

Table 8. Radioactivity in Glowegee Creek water and precipitation near the West Milton site, KAPL July–December 1966

Sampling period 1966	Average beta and gamma radioactivity (pCi/liter)		
	Glowegee Creek (upstream)	Glowegee Creek (downstream)	Precipitation
July	0±11	0±11	1.5$\times 10^3$
August	9±10	19±12	1.2$\times 10^3$
September	4±9	2±9	1.4$\times 10^3$
October	10±13	1±12	.3$\times 10^3$
November	3±2	1±3	1.4$\times 10^3$
December	14±8	11±8	0.5$\times 10^3$
July–December	7±9	6±9	1.1$\times 10^3$

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	October 1966
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3. S1C Prototype Reactor Facility July–December 1966 [5]

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype Reactor Facility is a land-based nuclear submarine power plant operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, Inc. The prototype contains a pressurized water reactor power plant which is used to conduct research and development work and to train personnel in the operation of naval reactor power plants. Reactor power operations at the S1C Prototype Facility began in December 1959.

The low-level radioactive waste discharged intermittently from S1C prototype operations

[5] Summarized from "S1C Prototype Reactor Facility Environmental Monitoring Report, July 1 through December 31, 1966" (CENRD–3163–RS–562).

consists mainly of water. Small quantities of airborne particulates in gaseous waste are also generated and released on occasion in the ventilation exhaust air.

Essentially all of the radioactive waste originates from the activation of minute amounts of impurities or corrosion products in the circulating water used as a reactor coolant. All materials released to the environment are routinely monitored to assure that waste disposal operations comply with AEC regulations.

Air monitoring

Ventilation air from the submarine hull and the supporting facility at the prototype site may contain small amounts of radioactive gases or particulates. This ventilation air is discharged to the environment through an exhaust stack. The ventilation air is continuously monitored for radioactivity by automated counters which control the discharge of the exhaust air. When the AEC maximum permissible concentration limits are exceeded, the exhaust air is discharged through a high-efficiency filter bank or the ventilation system is completely shut down and the hull sealed. In addition, air is continuously sampled for particulates at onsite and offsite locations shown in figure 3. Table 9 presents the average gross beta radioactivity concentrations detected at air monitoring stations during the third and fourth quarters of 1966.

Table 9. Gross beta radioactivity in continuous air samples, S1C, July–December 1966

Sampling locations	Concentration (pCi/m³)					
	July–September			October–December		
	Low	High	Average	Low	High	Average
Stack and hull exhausts	26	85	50	10	98	60
Onsite stations	0.12	1.6	0.9	0.23	2.5	.71
Offsite stations	.82	5.1	1.0	0.14	1.6	.81

Water monitoring

Liquid wastes are collected in 5,000 gallon retention tanks. If the radioactivity in a filled tank is below the allowable AEC limit for discharge to uncontrolled areas, the tank contents are released into the industrial waste system. If the limit is exceeded, the contents are diluted below the AEC radiation protection standard in a 25,000-gallon dilution tank and then released. Table 10 is a summary of the gross beta radioactivity released to the Farmington River during the second half of 1966. The concentration of specific radionuclides released to the river during this period are presented in table 11.

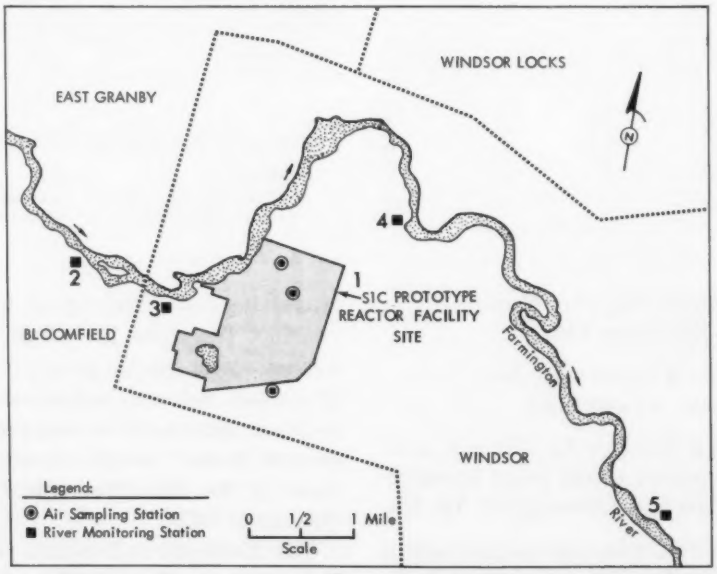

Figure 3. Environmental monitoring locations, S1C Prototype site

Table 10. Gross beta radioactivity released to the Farmington River, S1C, July–December 1966

Period	Total radioactivity (millicuries)	Average concentration (pCi/liter)
July–September	12.5	5.6×10^{1}
October–December	21.0	8.1×10^{1}

The Farmington River is sampled periodically at various locations as shown in figure 3 for determination of gross beta radioactivity in river water and mud. All 30 water samples contained less than the detectable level of 10 pCi/liter of gross beta radioactivity. All 11 mud samples contained less than the detectable level of 10 pCi/g of gross beta radioactivity.

Table 11. Concentration of specific radionuclides released to the Farmington River, S1C, July–December 1966

Radionuclide	Concentration (pCi/liter)	
	Average for second half 1966	Applicable AEC standard [a]
Cobalt-60	4.0×10^{1}	3×10^{4}
Iron-59	11.8×10^{2}	5×10^{4}
Manganese-54, Cobalt-58	4.1×10^{2}	9×10^{4}

[a] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation," contains the applicable AEC standards.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1965	October 1966
January–June 1966	April 1967

Reported Nuclear Detonations, September 1967

During September 1967, three U.S. underground nuclear tests were announced by the Atomic Energy Commission. The tests which were conducted underground on September 7 and September 27 at the Nevada Test Site were of low-intermediate yield (20 to 200 kilotons TNT equivalent). The underground test conducted on September 21 was of low yield (less than 20 kilotons TNT equivalent).

The test conducted on September 21 was part of the Plowshare Program to develop peaceful uses of nuclear explosives. This was an effort to develop special emplacement techniques designed to reduce the amount of radioactivity released to the atmosphere from possible later excavation experiments.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DIET MODEL FOR MEASURING RADIOACTIVITY EXPOSURE THROUGH FOOD-PILOT STUDY. *R. C. Steinkamp, N. L. Cohen, E. Hutson,* and *H. Kunkel. Radiological Health Data and Reports, Vol. 8, October 1967, pp. 565–573.*

This paper reports a pilot study designed to test the hypothesis that the house diet of a hospital may serve as a model for the diet of an adult population regionally served by the hospital in order to measure radioactivity exposure through food intake. Yearly and seasonal quantities of 37 subcategories of nine major food groups were compared for a Berkeley hospital house diet and diets of Berkeley and other San Francisco Bay Area residents. Results indicate that the hospital house diets while differing in certain respects from food intake of the population, may provide an estimate of near-maximum intake of foods significant for radioactive content.

KEYWORDS: California, diet, food, fruit, hospitals, milk, vegetables.

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A list of suggested keywords (descriptors) which are appropriate indexing terms should be given following the abstract.

Introductory paragraph: The purpose of the investigation should be stated as early as possible in the introductory paragraph.

Methods: For analytical, statistical, and theoretical methods that have appeared in published literature, a general description with references to sources is sufficient. New methods should be described clearly and concisely with emphasis on new features. Both old and new methods, materials, and equipment, should be described clearly enough so that limitations of measurements and calculations will be clear to the readers. Errors associated with analytical measurements and related calculations should be given either as general estimates in the text or for specific data in appropriate tables or graphs, whenever possible.

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